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OHIO RIVER BASIN COMPREHENSIVE SURVEY. VOLUME XIV. APPENDIX M. --ETC(U)

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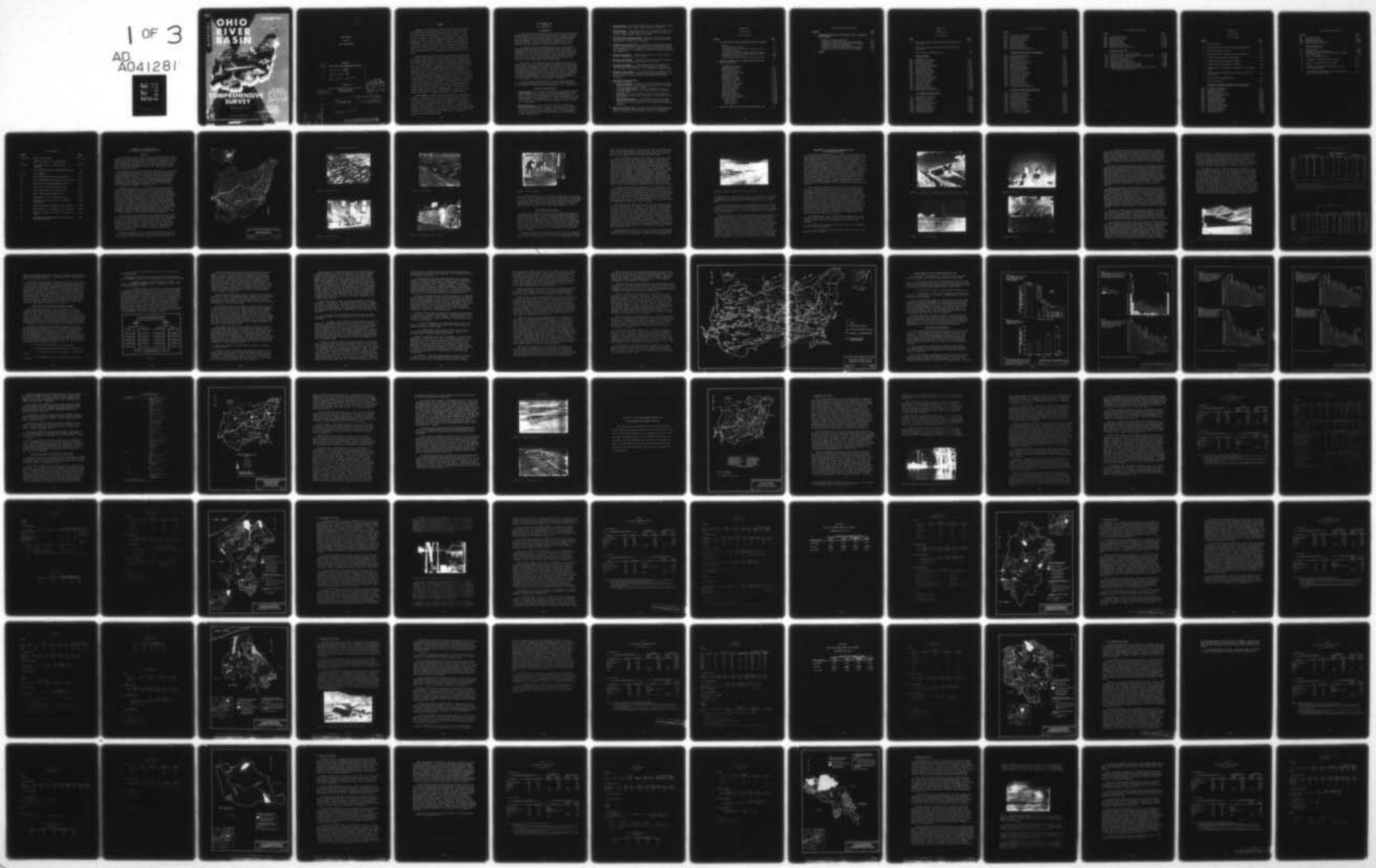

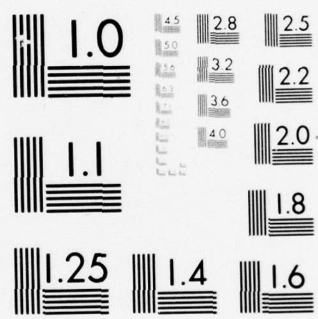

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VOLUME XIV

OHIO RIVER BASIN

COMPREHENSIVE SURVEY

Appendix M

Prepared by U.S. Army Engineer Division, Ohio River in cooperation with Departments of Agriculture; Commerce; Health, Education and Welfare; Interior; the Federal Power Commission and ...

FLOOD CONTROL

U.S. ARMY ENGINEER DIVISION, OHIO RIVER-CINCINNATI, OHIO

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FLOOD CONTROL

IN THE

OHIO RIVER BASIN

APPENDIX M

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OHIO RIVER BASIN COMPREHENSIVE SURVEY,

Volume ~~XIV~~.
Appendix M.
Flood Control.

Prepared by

U.S. Army Engineer Division, Ohio River
Corps of Engineers
Cincinnati, Ohio

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PREFACE

Although a major program of flood control has been very effective in the Ohio Basin, the problems continue to grow. Because of the existing and potential development in the Ohio River Basin it ranks as one of the major flood problem areas of the nation. Many of the flood plain lands are ideally located for industrial and commercial development, and by locating here these interests can take advantage of existing transportation facilities, water supplies, electrical power and a skilled labor market. Many of the flood plain lands are fertile and contribute to the important agricultural economy of the basin.

Greater attention has recently been focused on the consideration of preventing future damages in the development of these lands rather than reducing them after the structures are completed. Sediment control also is an important part of the flood control program and much can be done with land treatment and management and detention structures to not only prevent erosion, but capture the sediments to reduce damage to downstream areas. The control of high flows is a major part of future water and related land development. In implementing the storage portion of the framework program, multipurpose development and use of the individual projects and their systems benefits serve the people of the basin in both economic and social betterment. This appendix discusses the various flood problems and develops a program to reduce damages and protect flood plains for greater economic return. Since this is a framework plan, projects are not recommended for construction but the general relationship of problems and solutions are established.

Acknowledgement is made to those who cooperated in preparing this appendix. The assistance of the Soil Conservation Service, Economic Research Service and Forest Service of the Department of Agriculture, the Environmental Science Services Administration of the Department of Commerce, various agencies of the eleven states in the study region and the Miami Conservancy District for supplying information on flood damages and flood control programs and their contribution in preparing this appendix is especially appreciated.

FLOOD CONTROL STUDY
OF THE
OHIO RIVER BASIN

Introduction

On May 16, 1955, the Committee on Public Works of the United States Senate, adopted a resolution directing the Corps of Engineers to conduct a review of reports on the Ohio River "with a view to determine whether any modifications to the present comprehensive plan for flood control and other purposes in the Ohio River Basin is advisable at this time." The basic responsibility for the study was assigned to the Division Engineer, U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio.

In response to this and supplemental resolutions, the Ohio River Comprehensive Survey consisting of a Main Report and 13 Appendices, was undertaken. The objective of the Comprehensive Survey was to develop a Framework Plan for the Ohio River Basin which will provide a broad guide for the best use, or combination of uses, of the water and related land resources of the basin to meet foreseeable short and long term needs. This flood control study, Appendix M to the Survey, by the Corps of Engineers, is an integral part of that Framework Plan.

The purpose of this study is to identify present and future flood problem areas, their magnitude and potential solutions from a basin-wide viewpoint and to develop a basin-wide plan for needed control and prevention measures. Flood problems and their potential solutions from a basin-wide and sub-basin viewpoint are given in Sections I and II respectively. The flood control plan for the basin is given in Section III. Section IV includes the methodology used to (1) determine the present flood damages, (2) estimate future damages for projected conditions of development in flood plains and (3) inventory present and possible future control projects and programs. Section V is a summary of the appendix.

To provide a clear understanding of the terminology used herein, the following glossary of terms has been included. These definitions are considered to be compatible with existing definitions in general use.

Glossary of Appendix Terms

1. Upstream areas are above the point at which the drainage area approximates 250,000 acres. In general, these areas encompass minor tributaries. Normally watershed projects would provide protection for upstream agricultural flood plains and for those urbanized areas where flood problems of minor magnitude exist. Major flood control projects could be utilized in areas of large flood damages. Generally these are in urban areas.

2. Downstream areas are below the point at which the drainage area approximates 250,000 acres. In general, these areas cover sub-basin main stems and their major tributaries. Here reservoir and local flood control projects would provide protection for downstream agricultural flood plains and for urbanized areas where flood problems of major magnitude exist.

3. Flood of Record - Any flood for which there is a gage record or other systematic or reliable record useful for technical analysis.

4. Flood Frequency - The average interval of time, based on the period of record, between floods equal to or greater than a specified discharge or stage, generally expressed in years.

5. 100 Year Modified Frequency Flood - Represents a flood whose chance of occurrence is once in 100 years assuming all projects in the July 1965 flood control plan are in operation.

6. Standard Project Flood (SPF) - A hypothetical flood representing the critical volume and peak discharge that may be expected from the most severe combination of meteorologic and hydrologic conditions reasonably characteristic of the geographical region excluding extraordinarily rare combinations.

7. Natural Flood Damages - Damages that would occur if flood control or prevention measures were not in effect.

8. Modified Flood Damages - Damages that would occur after some degree of flood control or prevention measures are in effect.

9. Upstream Flood Damages - Those damages caused by floodwaters in upstream watershed of approximately 250,000 acres drainage area or less, excluding flood problems of major magnitude in urbanized areas.

10. Downstream Flood Damages - Those damages caused by floodwater below the point at which the drainage area approximates 250,000 acres. In general, these areas cover sub-basin main stems and their major tributaries.

11. July 1965 Flood Control Plan
    Includes the following:
    a. Corps of Engineers - Includes flood control reservoirs and local protection projects constructed, under construction or in preconstruction planning as of July 1965.
    b. Soil Conservation Service - Includes watershed projects constructed, under construction and those approved for operations as of July 1965.
    c. Non-Federal - Includes non-Federal constructed and under construction projects as listed in Appendix J, "State Laws, Policies and Programs."
    d. Non-Structural Measures - Includes measures such as the flood forecasting service of the Environmental Science Service Administration, flood plain evacuation, flood fighting and flood plain management.

12. Future Flood Control Plan - Includes future feasible Federal and non-Federal structural and non-structural flood control and prevention works and programs beyond the present program to the year 2020.

Appendix M

Flood Control

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SECTION I - OHIO RIVER BASIN
FLOOD PROBLEMS AND POTENTIAL SOLUTIONS

General

The study area for the Ohio River Basin Comprehensive Survey, represented by the shaded area in Figure 1, excludes the Tennessee River Basin, covers approximately 163,000 square miles, and has a population of about 20 million persons. Included in the study area are major portions of Ohio, Indiana, Kentucky and West Virginia; substantial parts of Pennsylvania, Illinois and Tennessee, and small areas of New York, Maryland, Virginia and North Carolina.

The Ohio River is formed at Pittsburgh, Pennsylvania, by the junction of the Allegheny and Monongahela Rivers which head on the western slopes of the Allegheny Mountains. From Pittsburgh, the Ohio flows generally southwest by west, 981 miles to its junction with the Mississippi River at Cairo, Illinois. The parent stream is joined by a number of major tributaries in its course: the Little Kanawha, Kanawha, Guyandotte, Big Sandy, Licking, Kentucky, Salt, Green, Cumberland and Tennessee from the south; and the Beaver, Muskingum, Hocking, Scioto, Little Miami, Great Miami and Wabash from the north.

The basin lies directly in the path usually followed by cyclonic disturbances as they move from west to east in the winter and early spring. For this reason, it frequently has more than normal rainfall from January to March, when infiltration, transpiration and evaporation are at a minimum, and rainfall-runoff relationships attain their maximum. This is a major factor accounting for the large flood flows likely to occur then. Another contributing factor is the rapid runoff caused by the precipitous slopes of the mountainous regions bordering the basin to the east and southeast. Furthermore, the basin's pear shape tends to synchronize flood flows originating in the upper or narrow portions with those of the three large tributaries draining the wide area toward the mouth, the Wabash, Cumberland and Tennessee Rivers. On the Ohio and tributaries, flood problems have been aggravated by encroachment of buildings, bridges, railroads, highways and other structures, drainage of forest swamp lands, improper land use and forest depletions.

In this century, the devastating floods of March 1913, March 1936, and January-February 1937, caused great economic losses and considerable loss of life. The 1937 flood was the most disastrous ever experienced in the basin causing damages in excess of $400 million. More than 500,000 persons were driven from their homes and 65 lost their lives. Virtually all rail, telegraph, telephone, power and highway facilities along the Ohio River and its major tributaries were interrupted for periods lasting from a week to a month. In general, business and industry were paralyzed.

Because of the basin size, no specific flood has been the maximum one of record throughout the basin. The 1937 flood was the highest in most sub-basins, particularly those in the lower Ohio River Basin. The

OHIO RIVER BASIN COMPREHENSIVE SURVEY

OHIO RIVER BASIN

CORPS OF ENGINEERS U S ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE 1

Past floods have resulted in

Photo 1. Economic losses.

Photo 2. Human suffering.

Photo 3. Loss of life.

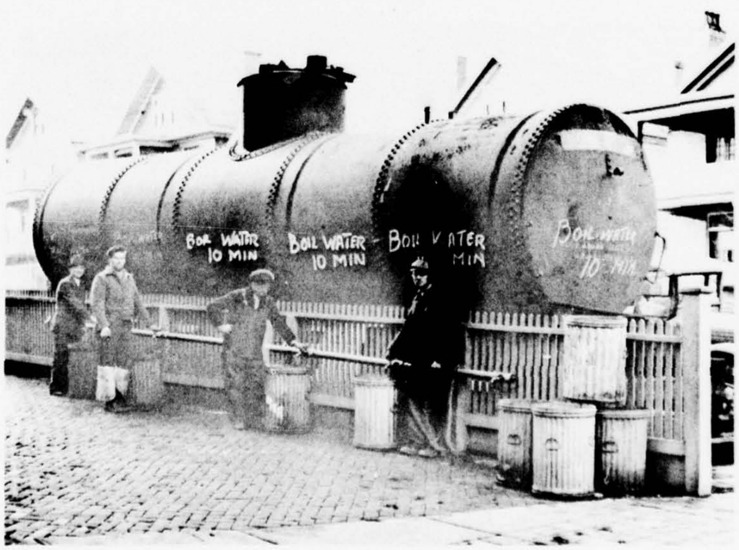


Photo 4. Contaminated water supplies.

Photo 5. Costly cleanups.

eastern sub-basins generally have recorded the 1936 flood as the maximum of record. The 1913 flood was centered over the tributaries in the middle of the basin, north of the Ohio. More recent floods such as January 1957, January 1959, March 1963, and March 1964, have generally caused the maximum recorded flows in several major Ohio River tributaries. On many smaller tributaries, local flash floods are the maximum of record.

Early Flood Control Efforts

Early efforts at flood control in the Ohio River Basin began about 1808 when private landowners built levees in the Wabash River Basin to protect their farm lands. Later, local groups built levees and walls to partly protect Shawneetown, Illinois; Portsmouth, Ohio; Lawrenceburg, Indiana, and other communities against Ohio River floods. Following the great flood of 1913, the Miami Conservancy District was formed by local interests and it built, without Federal or state aid, five control reservoirs and numerous local protection projects in the Great Miami River Basin. Other entities have followed this approach to solve local and tributary problems.

Federal interest and participation in flood control is an outgrowth of the Federal responsibility for navigation derived basically from the commerce clause of the Constitution. This Federal flood control activity

began in the alluvial valley of the Mississippi River and took definite form with the establishment of the Mississippi River Commission by Congress in 1879. That commission still has jurisdiction over the flood control and navigation work on the lower Mississippi River.

The first extension of Federal flood control activity outside the Mississippi River Valley developed with the passage of the River and Harbor Act of March 1, 1917. In this Act, Congress recognized the growing national concern with flood control, and its close relationship with navigation and other water-resource developments by prescribing that existing law relating to improvements of rivers and harbors (for navigation) should apply so far as applicable, to flood control. Among other effects this placed flood control generally under the jurisdiction of the Corps of Engineers. In addition the same Act specified that examinations and surveys for flood control should be comprehensive in scope and include consideration of the development of water power and such other uses "as may be properly related to or coordinated with the project." Although subsequent River and Harbor and Flood Control legislation has clarified and expanded this language, it remains the basic authority and directive for the comprehensive water resource studies made by the Corps of Engineers in carrying out the flood control program.

A broader factual basis for establishing a Federal program of flood control and water-resource development was made possible when, in the River and Harbor Act of 1927, Congress first authorized the prosecution by the Corps of Engineers of the comprehensive river-basin studies known as the "308" surveys (so called because authorization was based on House Document No. 308, 69th Congress, which indicated the surveys required and estimated their cost). The stated purpose of these surveys was to formulate general plans for improving the nation's rivers for navigation, power development, flood control, and irrigation.

The results of the "308" surveys on the Ohio River Basin were submitted to Congress August 14, 1935, and are published in House Document No. 306, 74th Congress, First Session. That document presented a plan for alleviation of floods on the Ohio River. The plan was under consideration when the great floods of 1936 and 1937 occurred. Following the latter, review of the report published in House Document No. 306 (together with other reports dealing with the Mississippi River and its other tributaries) was made to determine whether any modifications were warranted in view of the occurrence of these floods. The report on this is published in Flood Control Committee Document No. 1, House of Representatives, 75th Congress, First Session. It recommended a plan for flood control and other purposes in the Ohio River Basin. This document and subsequent studies by the Corps of Engineers were the basis for the 1938 Flood Control Act.

The development of Federal reservoirs in the Ohio River Basin began in 1934 when the Corps of Engineers, in cooperation with the Muskingum Conservancy District, constructed 14 reservoirs in the Muskingum Basin.

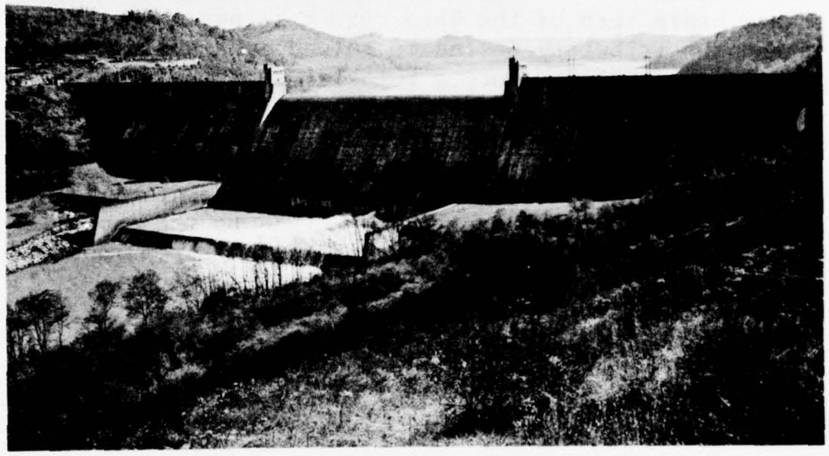


Photo 6. Tygart Dam, Tygart River, West Virginia.

In that same year at Shawneetown, Illinois, on the Ohio River the Corps of Engineers under authority of the 1928 Flood Control Act, raised and enlarged the existing levee which was originally built by the city in 1875.

Pictured is the Tygart Dam in the Monongahela River Basin which was authorized in 1934 and adopted by the 1935 River and Harbor Act. This was the first Federal reservoir in the Ohio Basin that provided storage for multipurpose uses, that is for low flow augmentation for navigation and for flood control.

The present Ohio River Basin Comprehensive Survey was authorized by a resolution adopted May 16, 1955, by the Committee on Public Works of the United States Senate. It requested a review of prior reports to determine if any modifications in the present comprehensive plan for flood control and other purposes in the Ohio River Basin were advisable. Studies under this authority were initiated in 1956. The early studies included hydrologic investigation, development of a standard project flood, review of the adequacy of local protection design floods for the Ohio main stem and development of natural flood and low flow frequencies. Further studies included investigation of flood damage relationships, development of modified floods, low flow frequencies, evolution of the adequacy of the current comprehensive plan of development and investigations of modifications of the plan to meet the basin needs.

Development of the Original Flood Control Plan for the Ohio River Basin

The concept for development of the original Ohio River Basin flood control plan was developed in the above mentioned basin-wide "308" surveys and subsequent studies. The development of a flood control plan for a large drainage basin such as the Ohio requires that the problems of the Ohio River and the tributary basins be solved on a system basis. Flood control plans were developed for tributaries, and their effect on the Ohio River was determined. Feasible modifications were made to the tributary plans from the standpoint of flood control on the Ohio. Additional measures providing floodwalls and levees were incorporated in the plan for the protection of Ohio River and other damage centers. In formulating the flood control plan, consideration was given to the economic value of each prospective project from the standpoint of other purposes such as navigation, water supply, water quality, hydroelectric power, fish and wildlife conservation and recreation to provide projects in the best interests of the general public. These procedures and principles established a well-balanced flood control plan, comprised of a system of reservoirs which provided basic control, supplemented by local protection projects.

The original flood control plan for the basin included the determination of a project flood for the Ohio River. This was derived as the maximum anticipated flood which would be caused by combinations of the severest general storms that have occurred in the various regions of the basin. The system of reservoirs authorized by the 1938 Flood Control Act and prior acts would reduce the 1937 project flood to stages very close to the maximum of record along the Ohio River from the mouth to Wellsville, Ohio, located at about Mile 932 above the mouth, and below stages of the flood of record between Pittsburgh and Wellsville. The project design flood profile then selected in 1937 for construction of local protection works on the Ohio River was established as the modified project flood between Pittsburgh and Cairo, and is equivalent to the maximum ones of record between Wellsville and the mouth of the Ohio River at Cairo, Illinois. Local protection works constructed on the Ohio River since 1937 provide three feet of freeboard above the grade of the project design flood profile.

The adopted plan for local flood protection provides relief from the 1937 project flood at those communities where floodwalls or levees are built, upon completion of the contemplated reservoir storage development.

The flood control features of the original flood control plan have evolved on the following basis:

a. All reservoirs considered meritorious from a system standpoint have been included.

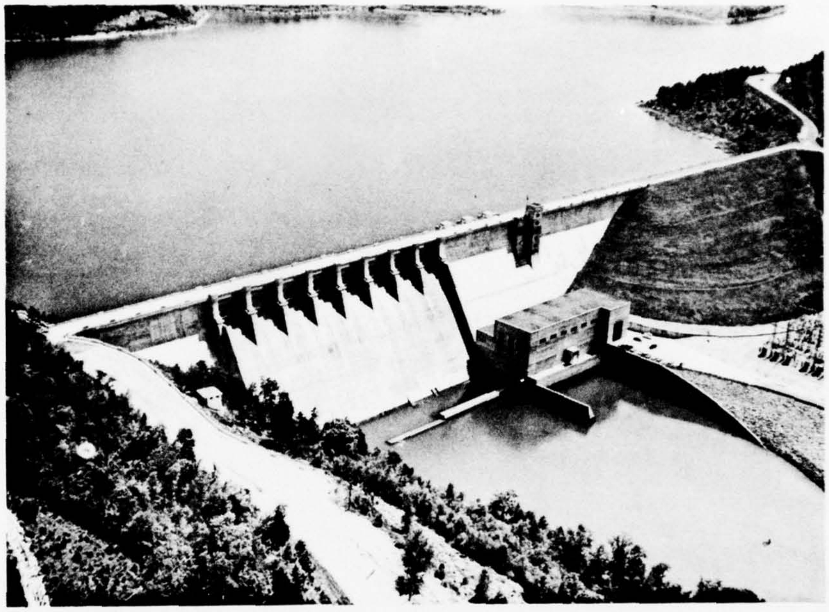


Photo 7. The Center Hill Multipurpose Reservoir, Caney Fork River, Tennessee, provides opportunities for flood control, power.....

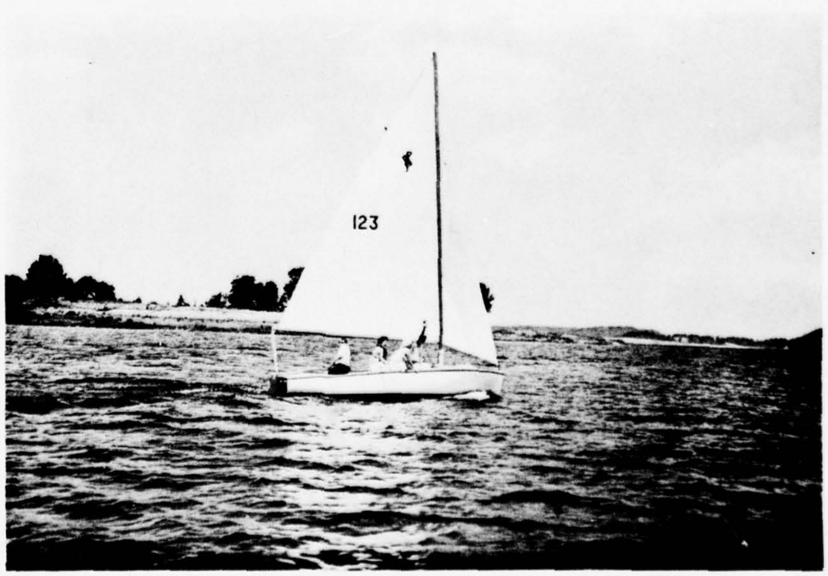


Photo 8. Recreational boating.

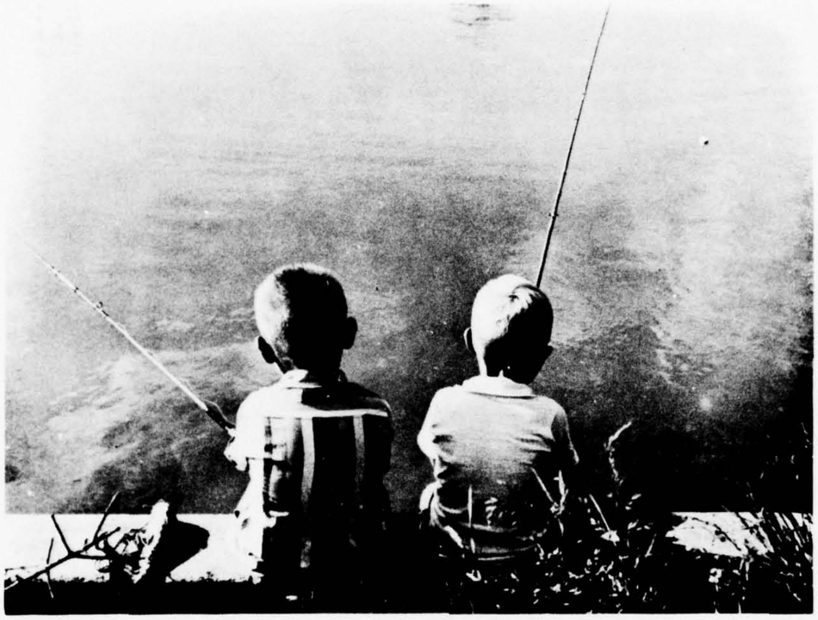


Photo 9. Fishing.

Photo 10. Camping.

b. Sufficient reservoir projects have been added to provide the dispersion of control required to assure that the system will reduce a flood of the magnitude of the 1937 project flood at all locations along the Ohio River, approximately to or below the stage of the maximum high water of record at these localities. In the selection of these projects, prime consideration was given to those reservoirs which would result in a maximum of local benefits and provide balance to the system regulation control.

The reservoirs in the original plan have been designed primarily for flood control on the Ohio River and its tributaries. In addition their operation will afford reductions in Ohio River contributions to flood flows on the Mississippi River, and further assure the adequacy of the authorized control plan for that river. The reservoirs have other water resource functions. Most of them in the plan have permanent or conservation pools which are of great value for recreation and for the preservation of fish and wildlife. Some afford a valuable increase in low-water flow on the Ohio and the tributaries, providing a benefit to navigation, improvement of water supplies and improved water quality. Some provide for the economic development of hydroelectric power and other functions.

The 1936 Flood Control Act authorized 14 reservoirs, 9 in the Allegheny and Monongahela River Basins in addition to the previously authorized Tygart Reservoir to protect Pittsburgh and other communities, and 5 in the Kanawha and Licking River Basins. In addition, 20 local protection projects in the Wabash River Basin and two in the Cumberland River Basin were authorized by the 1936 Flood Control Act. The Act also provided that Federal investigations of watersheds, measures for runoff and waterflow retardation, and soil erosion prevention were to be under the jurisdiction of the Department of Agriculture. Pursuant to this Act and amendatory legislation thereto, survey reports for the Green and Licking River Basins in Kentucky and the Scioto River Basin in Ohio were completed in the early 1950's.

The basic elements of the original plan were included in the 1938 Flood Control Act. It provided for 50 additional reservoirs in accordance with the previously mentioned concept for development of the Ohio River Basin flood control plan. Including those authorized by previous acts, the 1938 plan consisted of 79 reservoirs, 68 of which would significantly reduce Ohio River flood stages, and 235 local protection projects.

The original plan has been modified as a result of detailed studies of various elements as they were progressively developed. In accomplishing this, the original basin plan has been altered by adding numerous projects, deleting some and modifying features of others. As of July 1965, the flood control plan authorized for downstream areas consists of 98 reservoirs, 263 major local protection projects and 56 small flood control projects authorized under special continuing authorities. The status of the authorized plan for downstream areas is presently (as of July 1965) 40 reservoirs, 62 major and 51 small local protection projects completed; 24 reservoirs, 17 major and three small local protection projects under

under construction; 11 reservoirs, and seven major and two small local protection projects in preconstruction planning; and 23 reservoirs and 177 major local protection projects authorized but not started. The total cost of the projects completed, under construction and in preconstruction planning is about $1.8 billion, and they contain about 17 million acre-feet of flood control storage, 372 miles of levees and floodwalls, and 207 miles of channel improvement. (Table 1). Detailed information on them, including location, is given in Section II.

In response to national interests for upstream management, the basin's watershed program was initiated through pilot projects in 1953, and subsequently enacted Public Law 566, the Watershed Protection and Flood Prevention Act, in 1954. This was an attempt to fill the gap in resource development between major flood control projects and individual on-farm conservation measures. In so doing, the benefits of combining soil and water conservation on the land with upstream flood prevention structures were recognized. By July 1965, 74 watershed projects had been authorized for construction in the basin. (Table 2). They include 961 miles of channel improvements and 440 floodwater retarding structures which will store 44,036 acre-feet of sediment and 284,204 acre-feet of floodwater, thus protecting 205,045 acres of flood plain. These projects also include purposes other than flood prevention which are presented in Appendix F. The Department of Agriculture provides technical and financial assistance in their planning and development. Local and state

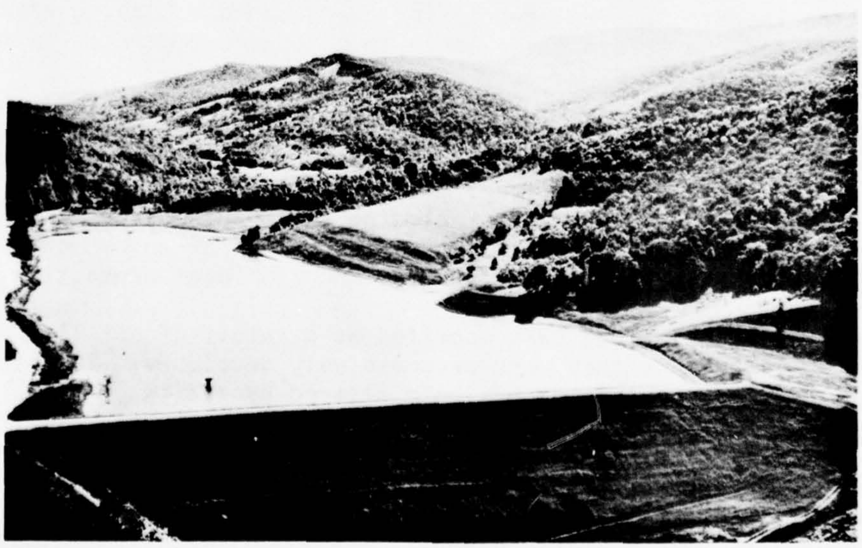


Photo 11. A multipurpose upstream PL 566 watershed project.

Table 1

SUMMARY OF DOWNSTREAM FLOOD CONTROL PROJECT DATA AS OF JULY 1965(1)

Sub-Basin	Reservoirs: Number	Reservoirs: Drainage Area Controlled (Sq Mi)	Reservoirs: Flood Control Storage (1,000 Ac Ft)	Reservoirs: Cost ($ Million)	Major Local Protection Projects — Levees, Floodwalls & Channels: Number	Length of Levees & Walls (Miles)	Length of Channel Improvements (Miles)	Cost ($ Million)	Small Local Protection Projects: Number	Small Local Protection Projects: Cost ($ Million)	Total Cost ($ Million)
Allegheny	10	5,317	1,712.8	213.9	14	20.3	34.7	39.3	11	1.14	254.3
Monongahela	2	1,618	429.0	29.3	3	0.7	12.3	18.4	7	0.32	48.0
Beaver	4	1,016	302.9	59.8	2	-	6.4	4.1	-	-	63.9
Muskingum	16	5,060	1,603.7	76.3	4	5.0	10.6	10.1	2	0.06	86.5
Little Kanawha	-	-	-	-	-	-	-	-	1	0.03	-
Hocking	1	33	17.6	3.0	-	-	-	-	-	-	3.0
Kanawha	3	5,905	1,252.1	113.7	3	-	10.9	1.9	4	0.25	115.8
Guyandotte	1	540	181.7	82.7	1	-	-	0.2	-	-	82.9
Big Sandy	4	842	339.3	88.5	1	0.4	-	1.1	3	0.46	90.1
Scioto	5	1,965	580.4	100.0	-	-	-	-	-	-	100.0
Little Miami	2	579	359.1	49.8	-	-	-	-	-	-	49.8
Great Miami(2)	2	461	247.6	43.9	-	-	-	-	-	-	43.9
Licking	1	826	438.5	28.9	-	-	-	-	-	-	28.9
Kentucky	5	1,663	910.4	88.3	2	0.7	Minor	0.2	3	0.27	88.8
Salt	-	-	-	-	1	8.1	-	0.4	3	0.05	0.5
Green	4	2,779	2,051.9	79.7	1	-	64.0	(3)	2	0.08	79.8
Wabash	6	3,016	1,321.0	74.9	17	184.6	5.0	37.1	4	0.32	112.3
Cumberland	5	17,598	5,031.0	341.4	5	6.3	6.6	7.0	1	0.58	349.0
Ohio River Minor Tributaries	4	437	214.3	60.2	5	15.8	53.6	13.4	15	2.00	75.6
Ohio River	-	-	-	-	27	130.3	2.4	125.9	-	-	125.9
TOTAL	75	49,655	16,993.1	1,534.3	86	372.2	206.5	259.1	56	5.56	1,799.0

NOTES: (1) Includes only those Corps of Engineers projects constructed, under construction, and in preconstruction planning. For number and description of non-Federal projects see sub-basin writeups under Section II.

(2) Does not include five detention type flood control reservoirs and local protection projects at 12 communities constructed by the Miami Conservancy District in the Great Miami sub-basin. The five reservoirs have a capacity of 841,000 acre-feet for flood control and the local protection projects include approximately 53 miles of levees and 43 miles of channel improvement.

(3) Cost of channel improvement included in reservoir costs.

Table 2

SUMMARY OF UPSTREAM FLOOD CONTROL PROJECT DATA AS OF JULY 1965(1)

Sub-Basins	Number of Projects	Total Area of Watersheds (Sq Mi)	Number of Dams	Drainage Area Above Dams (Sq Mi)	STORAGE: Sediment (Ac Ft)	STORAGE: Floodwater(2) (Ac Ft)	STORAGE: Other Uses(3) (Ac Ft)	STORAGE: Total (Ac Ft)	Surface Area: Sediment Pool (Acres)	Surface Area: Flood Pool (Acres)	Channel Improvements (Miles)	Total Estimated Flood Prevention Cost ($1,000)	Flood Plain Area (Acres)
Allegheny	4	492	27	180	1,241	26,298	25,863	53,402	296	6,050	31	3,488	12,096
Monongahela	7	124	30	46	1,043	7,764	780	9,587	195	785	16	3,339	2,328
Beaver	2	120	10	64	281	7,831	2,505	10,617	33	1,575	-	1,726	540
Muskingum	1	188	9	39	406	6,294	2,767	9,467	107	944	33	2,030	10,300
Little Kanawha	2	64	6	20	316	4,040	147	4,503	40	213	6	984	1,168
Hocking	2	286	31	121	6,593	18,426	2,252	27,271	517	2,660	28	5,237	14,063
Kanawha	5	87	19	21	385	4,188	525	5,098	85	459	23	2,072	2,437
Great Miami	2	80	11	26	266	5,450	101	5,817	33	380	22	1,562	2,650
Licking	1	27	2	2	35	330	-	365	14	57	4	42	817
Kentucky	1	24	-	-	-	-	-	-	-	-	6	165	336
Salt	1	37	12	11	304	2,163	-	2,467	70	258	21	343	1,253
Green	12	1,293	89	509	12,855	73,592	18,075	104,522	2,520	8,577	206	12,968	52,149
Wabash	16	1,253	78	350	8,180	55,072	19,019	82,271	1,819	8,781	306	14,850	48,301
Cumberland	6	306	24	151	2,472	18,582	3,674	24,728	323	2,084	48	4,200	8,385
Ohio River Minor Tributaries	12	999	92	334	9,659	54,174	9,112	72,945	2,190	6,850	211	13,175	47,952
TOTAL	74	5,380	440	1,874	44,036	284,204	84,820	413,060	8,242	39,673	961	66,181	205,045

NOTES: (1) Includes those upstream watershed projects authorized as of July 1965.

(2) To crest of emergency spillway.

(3) Storage for beneficial uses other than flood prevention.

agencies have program formulation, sponsorship, operation and maintenance and certain financial obligations. Information on them, including location, is given in Section II.

For purposes of this appendix, those reservoirs and local protection projects of the original plan that are completed, under construction or in preconstruction planning and those upstream watershed projects constructed, under construction, and approved for operation as of July 1965 are included in the July 1965 flood control plan. Average annual flood damages and 100 year modified frequency flood damages were computed assuming these projects were in operation as of July 1965. The 23 reservoirs and 177 major local protection projects in the original plan that are authorized, but not started, were examined as to their potential for future construction. Those projects in the authorized plan that do have a potential for future construction, plus projects not now authorized (as of July 1965) but having a potential for future construction were included in the potential future flood control plan.

Flood Control and Flood Damage Prevention Programs

The current Ohio River Basin plan for flood control includes an integrated Federal and non-Federal program consisting of a system of reservoirs, local protection projects and watershed projects on tributaries and local protection projects along the Ohio River. Also, various types of non-structural measures have been undertaken and more are planned in certain flood plains. Some of these are discussed in subsequent paragraphs. Comprehensive flood control and damage prevention programs which include flood plain land use regulation and other non-structural measures are inadequate at present, but much progress is being made in some areas.

Recently a Presidential Task Force Report entitled, "A Unified National Program for Managing Flood Losses," published as House Document No. 465, 89th Congress, Second Session, recommended a broader and more unified national program for managing flood losses, with emphasis on non-structural methods of reducing flood losses. In carrying out one of the recommendations of the Task Force, the President issued Executive Order No. 11296 directing all Federal agencies to evaluate flood hazards in locating Federally-owned or financed buildings, roads and other facilities, and in disposing of Federal lands and properties. The Task Force's recommendations are summarized as follows:

a. To improve basic knowledge about flood hazards.

b. To coordinate and plan new developments on the flood plain.

c. To provide technical services to managers of flood plain property.

d. To move toward a practical national program for flood insurance.

e. To adjust Federal flood control policy to sound criteria and changing needs.

Comprehensive flood control and flood damage prevention programs that are needed in the basin can be categorized under two general headings:

a. Corrective Measures to deal with existing problems. They include flood control structural measures to reduce the severity of the problem and emergency measures.

b. Preventive Measures which attempt to mitigate flood damages associated with future development and use of the flood plain by means of regulations, public development policies, building codes and zoning. In other words, corrective measures try to keep natural water away from man and his developments in the flood plain, while preventive measures try to keep man and his developments away from water. See Figure 2 for both classifications. Neither the present or future flood control program will eliminate all damages. In many areas complete protection is not economically feasible. Where protection is provided by levees, reservoirs, etc., flood losses are prevented only when floods do not exceed the project design flood. Rather than have a false sense of security, users of flood plains should be made aware of potential hazards and encouraged to avail themselves of one or a combination of the non-structural measures discussed in subsequent paragraphs.

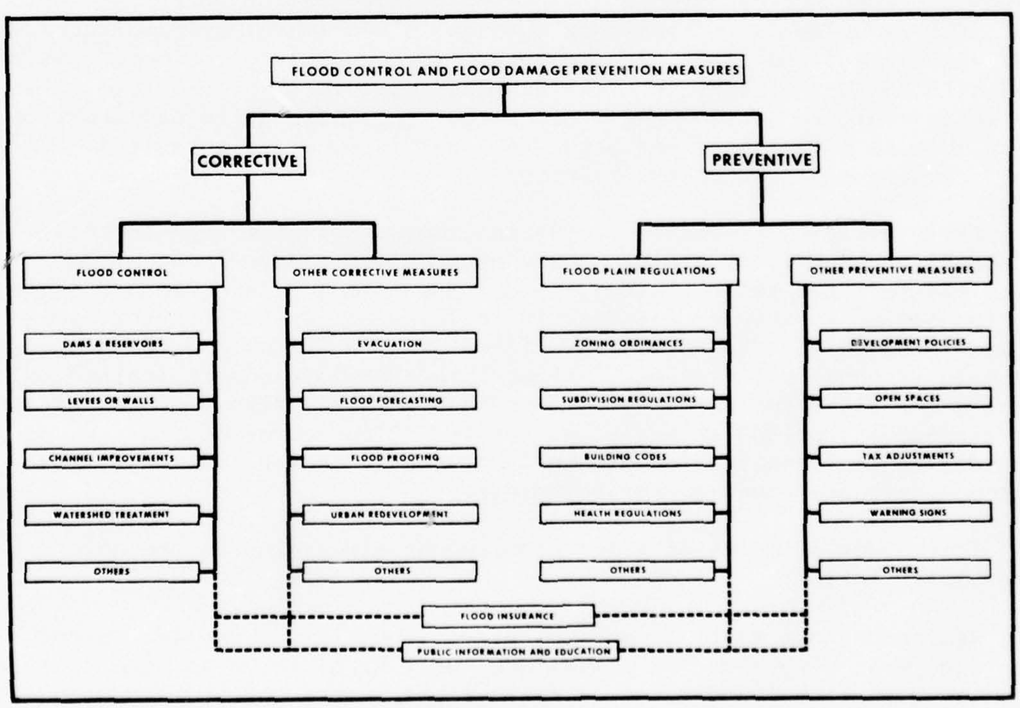


Figure 2.

Physical protection from floods is generally referred to as flood control, but this does not mean complete elimination of the hazard. Rather it provides a certain amount of protection by virtue of stage reduction through storage and barriers to prevent damaging encroachment of waters. It generally consists of dams and reservoirs, floodwalls and levee systems, channel improvements and flood-proofing of individual structures. Dams and reservoirs may range from major structures providing operational controls of floods to detention basins with uncontrolled outlets. Levees include embankments along rivers, concrete floodwalls through urban areas and dikes around individual structures. Channel improvements include clearing, enlarging, straightening and lining to reduce friction losses.

Upstream watershed protection projects include both structural and non-structural land use management measures. These are aimed at retaining water where it falls, either through increased absorption into the soil or through retarding structures. These projects basically involve a combination of land management practices and structural measures, whether on agricultural, forest or other areas.

Flood-proofing refers to the reduction of damage losses through the protection of individual buildings, enabling them to withstand moderate or low inundation with little or no damage, especially if the exposure is for only a short period of time. These techniques include check valves on sewer outlets, temporary bulkheads for sealing door openings, pumps for removing water caused by leakage, elevation of critical equipment above the flood line, and the like. This work is often most feasible when used to augment other protection measures. It is of greatest value for industrial, commercial and other structures whose solid construction helps them to withstand flood pressures, but is usually impractical for residences, except for basement areas.

Prime examples of the foregoing are those that have been undertaken in the Pittsburgh flood plain. The management of a department store, which had suffered severe losses in the 1936 flood, reinforced and sealed the foundation to prevent seepage, installed sewer shutoff valves, prepared window bulkheads and entrance flood gates and provided for sump pumps to dispense with seepage inflow. Store employees were trained to prepare the store for flood conditions in one hour. Also, when a portion of Pittsburgh's golden triangle was rebuilt, flood-proofing measures were included in the construction of the four Gateway Center buildings, the Hilton Hotel, and other nearby buildings.

Some other examples of flood-proofing of structures in the Ohio River Basin follow:

Residences and small commercial establishments on Wheeling Island, Wheeling, West Virginia, and at Wallace, West Virginia, have been constructed with high foundations to raise first floors above the average flood level. At Ohio University, Athens, first floors of flood plain buildings are being designed and utilized for parking or other uses that will minimize damages and enable their early evacuation.

Flood insurance is included as a potential non-structural measure. It might deal with either existing conditions or with future developments within the flood plain as an alternative to structural control measures or limitations as to use. Instead of attempting to reduce damage, flood insurance would tend toward spreading the burden of the losses over a widespread area of economic development and a period of time. The reason that flood insurance has been essentially unavailable and presently impractical as a private enterprise is because the inundations do not have the random nature necessary to a sound underwriting program. Almost all structures are potentially subject to fire damage whereas, only those structures within the flood plain are susceptible to water losses. Moreover, when a flood does occur, a high percentage of those structures insured would be affected. This would result in a heavy demand on the capital resources of the insurance programs. Also, it appears that flood insurance could not be sold at reasonable rates without sizable subsidies.

Urban renewal offers a means for handling situations of existing development in flood plains. Such areas may be deteriorated or blighted due to their susceptibility to flooding, and for that reason may qualify for inclusion in the program. The renewal program can be used to remove structures from overflow areas and to develop flood plain uses which are more compatible with conditions. Redevelopment in flood areas can follow two forms:

a. To clear the area completely and hold the land for future development consistent with the flood hazard, such as parks and recreation areas.

b. To provide a certain degree of flood protection for existing structures. The Federal urban renewal regulations make it clear that flood protection must be secondary to the elimination of slums and blight. Funds appropriated under Title 1 of the Housing Act of 1954 may not be used for a project for which the provision of flood protection is the primary objective. This means that urban renewal would not be a feasible method of acquiring land for a major levee or floodwall, but it could be used to provide flood protection for development within the project area. The protective works would have to lie wholly within the project area and be no more extensive than those necessary to protect the proposed land uses in the project area.

Flood plain information studies have been successful in alerting the public to problem areas and helpful in providing the basis for initiating the necessary action to alleviate water damages. The most recent statement on general authority for flood plain information studies is contained in Section 206, Public Law 89-789, approved November 7, 1966. The purpose is to make these studies readily available to Federal agencies, states, local governments, interested agencies and citizens for appropriate planning in their use. These reports provide basic data concerning the flood potentials and conditions that are of much value in the establishment of land use regulations, reserving channel space and planning of structures adjacent to or crossing the area. As of September 1967 there are 43 areas

within the basin for which flood plain information studies have been authorized at a total cost of about $830,000. Their location and status are discussed in Section II.

Two communities with recently completed flood plain information studies, Clarksville and Murfreesboro, Tennessee, have prepared zoning ordinances to regulate certain flood plain developments. Clarksville now utilizes information from its study as a guide in approving or disapproving applications for residential developments. The studies also have provided interested citizens, industries, business and local planning groups with much needed information. As more studies are completed, additional actions are expected to be initiated for flood plain regulations and other preventive measures at numerous localities.

Authority to regulate land use, including flood plains, is generally with non-Federal interests, Federal authority being limited to Federally-owned or sponsored property. Cities and counties may have the authority over land use as granted to them by the state. The states usually hold the basic responsibility to control flood plain development. Many states have acted through cities and counties to establish and enforce such regulations. Because of this, local planning is often an important beginning for such action. Some examples of the types of action that can be taken are given in subsequent paragraphs.

Zoning is presently the most common tool for regulating development in flood plains. A community can designate a flood-hazard zone, indicating the uses permitted in it, and can enforce these provisions just as it would in other parts of the zoning ordinance. These ordinances could accomplish the following:

a. Forbid encroachments on channels which would increase the height and effect of a flood, thereby causing additional damage to the property of others along the stream.

b. Prevent persons from being victimized by the purchase of flood plain property, where the full danger of water damage is not generally known or cannot be readily ascertained.

Subdivision regulations can reduce flood hazards by controlling new developments in the flood plains. This is especially valuable in areas presently outside the highly developed urban sections where much new development will occur. These are often beyond the corporate limits where municipal zoning controls that may be adequate are inapplicable. Comprehensive subdivision regulations should at least include, but not be limited to, the following requirements: a minimum building elevation, an indication on the plat of those areas subject to flooding, and a description of the subdivider's responsibility for maintaining open floodway areas.

Two examples of subdivision regulations which have been undertaken in the basin follow: The metropolitan government of Nashville and Davidson County, Tennessee, has adopted certain standards regarding

areas subject to flooding. The plat for areas subject to overflow from the Cumberland River or any other natural stream of the area must clearly show the limits of all portions of land subject to inundation and the elevation of the maximum flood of record (observed or calculated). Lots to be used for residential and retail commercial structures must have a ground elevation equal to or greater than the stage of the maximum record flood. Other structures have this same requirement, except if overflow is from the Cumberland River, the ground elevation must be equal to or greater than a calculated 25-year frequency flood.

Aurora, Indiana has relied upon emergency and non-structural measures for curbing flood losses in the past. It recently adopted regulations that provide for a number of structural adjustments to buildings and measures to prohibit subdivision of land subject to periodic flooding.

Building construction can be regulated by various health and building ordinances and codes. Many locations have enacted building codes specifying type of construction to be permitted. Communities which wish to undertake urban renewal or public housing are required to adopt codes as part of their workable program for community improvement. These and similar building codes could be used to specify the type of construction permitted in flood plain areas and required proofing measures similar to regulations commonly in effect concerning safety, health and fireproofing of structures. Health codes also serve as a developmental control, for subdivisions must obtain the approval of county health officers as to their water and sewage treatment facilities.

Property tax is becoming increasingly important in shaping land development. In rapidly urbanizing areas there may be a tendency to assess land on its potential value for development, rather than on the less intensive agricultural or open use to which it is being utilized. This may tend to force land upon the market sooner than would be the case. The heavy assessments may also tend to encourage development of undesirable building areas, such as flood plains, which should remain in less intensive uses. The influence of taxes on the development should be considered by the locality at the same time that it designates flood plain areas in zoning or subdivision regulations. Tax policy should work with rather than against other land use controls. Areas designated as floodways or flood plains should be zoned and assessed on their value for crops, or other open areas rather than on their value for building sites. Consideration should also be given to high tax levies on developments allowed in the flood plain that are commensurate with the public flood damage liabilities created with the development.

Some existing developments can be economically relocated out of reach of floods as an alternate to control measures. Although there are many problems associated with this type of solution, greater consideration should be given to flood plain evacuation in long-range planning. Existing laws and governmental policies do not adequately provide for application of this type of flood control or preventive measures.

Public facilities in the flood plain, especially bridges and fills, obstruct the flow of water and increase flood heights upstream. Also, they have an impact on the location of private development. A new highway, unless its access is controlled, will quickly attract ribbons of houses, gas stations, and assorted commercial uses, without adequate consideration of the potential flood hazard.

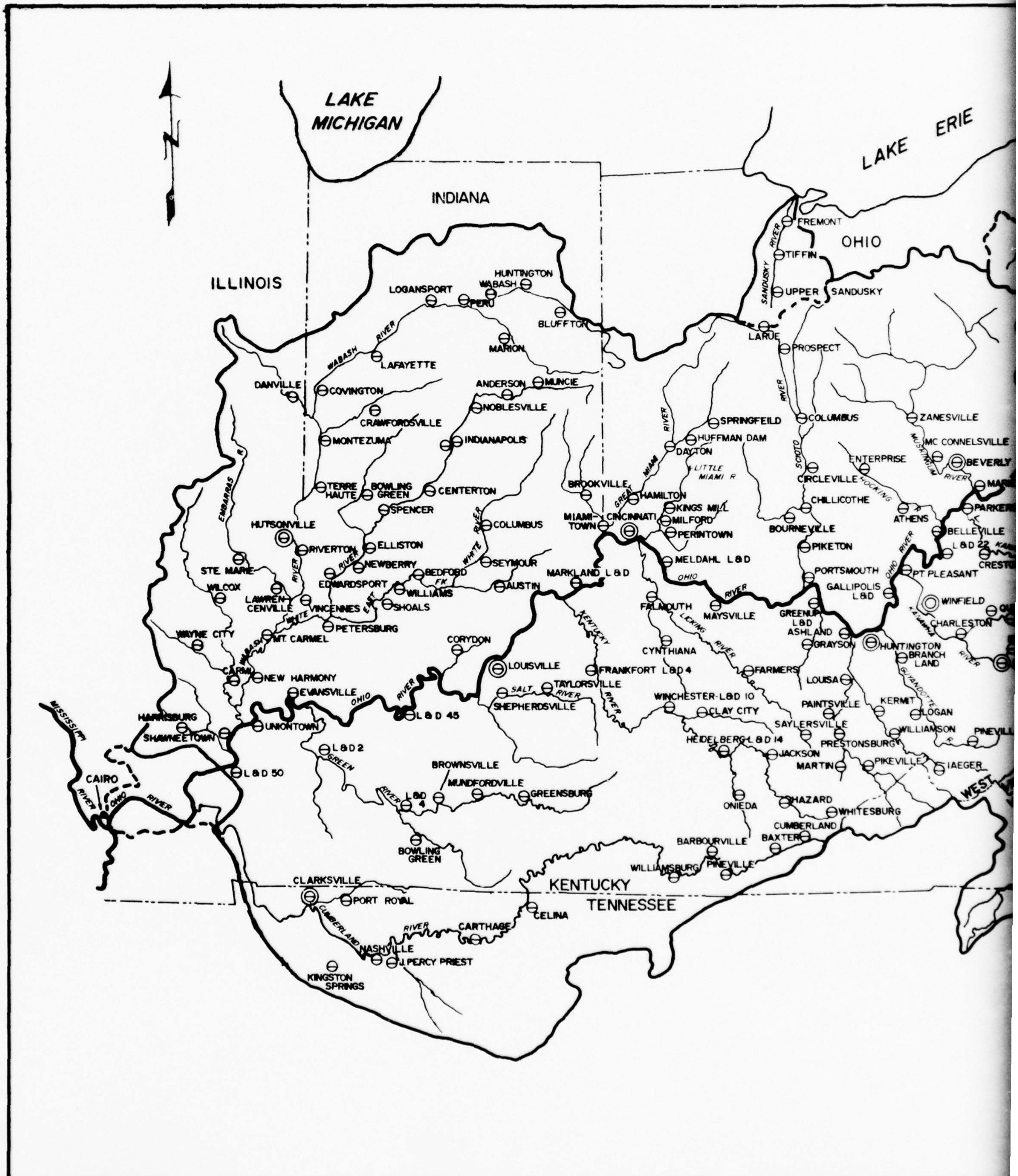
The Weather Bureau of the Environmental Science Services Administration operates a flood forecasting service for the Ohio River and its major tributaries. This service, in the form of forecasts and warnings, in most instances provides time for evacuation of people, for emergency protection of property and removal of some contents of flood plains.

The Ohio River Basin is divided into nine river districts, each served by a first-order Weather Bureau Office. These are Pittsburgh, Huntington, Columbus, Cincinnati, Louisville, Indianapolis, Evansville, Nashville and Cairo. These river district offices, as they are called, serve a two-fold purpose. First, they administer their portion of the observational network of river and rainfall stations; and they collect and relay the reports, as often as every six hours, to the appropriate River Forecast Center. Secondly, on receipt of the river forecasts from these centers, the district offices disseminate the forecasts to all interests concerned by the fastest means possible, mainly by radio and telephone. In short, these district offices serve the public, the forecast centers serve the river district offices.

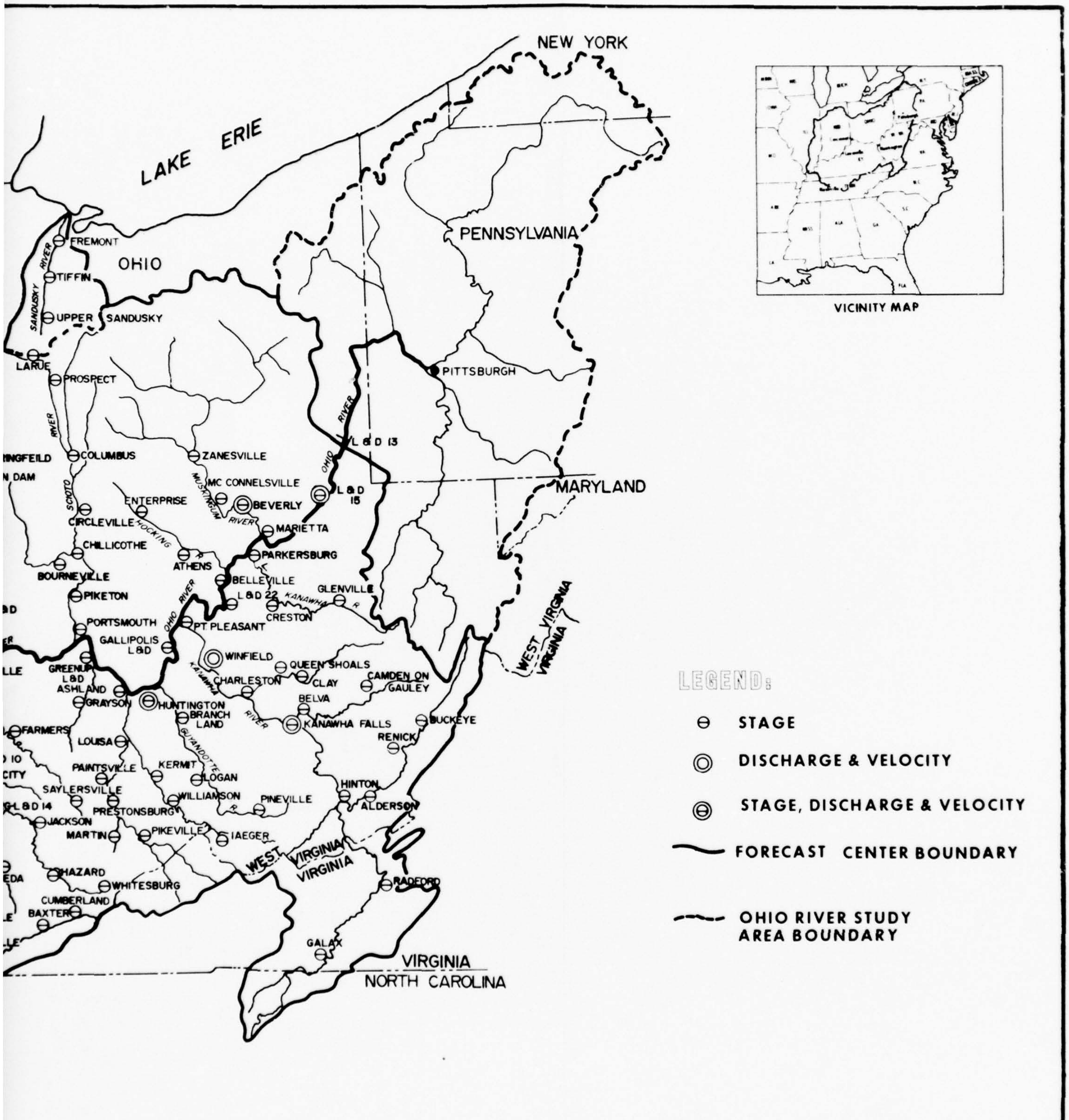
There are three River Forecast centers serving the Ohio River Basin. The unit at Pittsburgh, a cooperative enterprise with the Commonwealth of Pennsylvania, is responsible for preparing forecasts for the Ohio and its tributaries as far downstream as Dam No. 13, McMechen, West Virginia. Cincinnati as shown in Figure 3 has the long reach from Dam No. 13 to Dam No. 50, Fords Ferry, Kentucky. Kansas City has the last leg, Dam No. 50 to Cairo, Illinois.

The flood warning system requires only a few hours to alert the public; however, it may take too much time to be useful for flash flood warnings on small tributaries. For this reason, the Weather Bureau maintains a flash flood warning system utilizing local observers. The observers are supplied with rainfall gauges and charts to calculate the probable run-off rates and flood heights for an impending flood. Radio and television weather reports and news flashes are of much value. Additional procedures are being sought to improve the system.

Past est~~imates~~ by the Weather Bureau have indicated that flood warning systems have saved about 10 percent of potential flood damages and have reduced the potential loss of life probably by 90 percent or more. Later data from more recent events indicate savings from warnings far exceed the estimated savings.



N
LAKE MICHIGAN
LAKE ERIE
INDIANA
ILLINOIS
OHIO
KENTUCKY
TENNESSEE
WEST
FREMONT
TIFFIN
SANDUSKY RIVER
UPPER SANDUSKY
LARUE
PROSPECT
COLUMBUS
ZANESVILLE
MC CONNELSVILLE
MUSKINGUM RIVER
BEVERLY
ENTERPRISE
HOCKING R
ATHENS
CIRCLEVILLE
CHILLICOTHE
SCIOTO RIVER
BOURNEVILLE
PIKETON
PORTSMOUTH
PARKERS
BELLEVILLE
L&D 22
CRESTO
PT PLEASANT
GALLIPOLIS L&D
OHIO RIVER
WINFIELD
KANAWHA
CHARLESTON
HUNTINGTON
BRANCH LAND
GUYANDOTTE R
RIVER
SPRINGFEILD
HUFFMAN DAM
DAYTON
LITTLE MIAMI R
GREAT MIAMI RIVER
HAMILTON
KINGS MILL
MILFORD
PERINTOWN
MIAMI-TOWN
CINCINNATI
MELDAHL L&D
MARKLAND L&D
OHIO RIVER
MAYSVILLE
FALMOUTH
LICKING RIVER
GREENUP L&D
ASHLAND
GRAYSON
CYNTHIANA
FARMERS
LOUISA
PAINTSVILLE
KERMIT
LOGAN
WILLIAMSON
PINEVILLE
SAYLERSVILLE
PRESTONSBURG
PIKEVILLE
IAEGER
WINCHESTER-L&D 10
CLAY CITY
HEIDELBERG-L&D 14
JACKSON
MARTIN
ONIEDA
HAZARD
WHITESBURG
CUMBERLAND
BAXTER
BARBOURVILLE
PINEVILLE
WILLIAMSBURG
FRANKFORT L&D 4
KENTUCKY RIVER
TAYLORSVILLE
SALT RIVER
SHEPHERDSVILLE
LOUISVILLE
CORYDON
HUNTINGTON
WABASH
LOGANSPORT
PERU
BLUFFTON
MARION
WABASH RIVER
LAFAYETTE
DANVILLE
COVINGTON
ANDERSON
MUNCIE
NOBLESVILLE
CRAWFORDSVILLE
MONTEZUMA
INDIANAPOLIS
BROOKVILLE
TERRE HAUTE
BOWLING GREEN
CENTERTON
SPENCER
COLUMBUS
WHITE RIVER
HUTSONVILLE
RIVERTON
ELLISTON
NEWBERRY
SEYMOUR
EDWARDSPORT
BEDFORD
EAST FK
WILLIAMS
AUSTIN
SHOALS
EMBARRAS R
STE. MARIE
WILCOX
LAWRENCEVILLE
VINCENNES
WHITE
PETERSBURG
WAYNE CITY
MT. CARMEL
WABASH
CARMI
NEW HARMONY
EVANSVILLE
OHIO RIVER
L&D 45
HARRISBURG
SHAWNEETOWN
UNIONTOWN
L&D 50
MISSISSIPPI
CAIRO
RIVER
OHIO
RIVER
L&D 2
GREEN RIVER
BROWNSVILLE
MUNFORDVILLE
GREENSBURG
L&D 4
BOWLING GREEN
CLARKSVILLE
PORT ROYAL
CELINA
CUMBERLAND
RIVER
CARTHAGE
NASHVILLE
J. PERCY PRIEST
KINGSTON SPRINGS



OHIO RIVER BASIN COMPREHENSIVE SURVEY

STREAMFLOW FORECAST POINTS
CINCINNATI FORECAST CENTER

WEATHER BUREAU — U.S. DEPT OF COMMERCE
APPENDIX M — FIGURE 3

Effectiveness of the July 1965 Flood Control Plan

An assessment of the effectiveness to date of the July 1965 flood control plan reveals the following accomplishments have been made:

a. The virtual elimination of the probability and risk of major disasters from riverine flooding at many cities and localities where great loss of life and extraordinary property damages had been experienced before the Federal Government assumed responsibility for flood control.

b. A significant reduction in average annual flood losses; and

c. The evolution of the concept of comprehensive and coordinated programs for the development utilization, and conservation of the basin's water and related resources.

Long time average flood damages for the Ohio River Basin under 1965 conditions of prices and development would be $350 million annually were it not for the present flood control and flood damage prevention plans, which reduce flood damages to about $111 million annually. Of the $239 million in damages preventable, reservoirs accounted for $160 million, flood forecasting $34 million, local protection projects $28 million, non-structural measures other than flood forecasting $15 million, and upstream watershed projects $2 million. (Figure 4).

The effectiveness of July 1965 flood control and flood damage prevention programs can also be measured in terms of flood plain acreage receiving protection. There are an estimated eight million acres in the flood plains of the Ohio River Basin which require control of high flows. Presently about 3.6 million acres receive some protection, with about 865,000 acres receiving a relatively high degree of protection.

The Remaining Flood Problem

Of the current residual average annual damages of $111 million, $58 million are in downstream areas and $53 million are in upstream areas. (Figure 5). If the projected rate of the growth in the basin's flood plain occurs, the residual flood damages are projected to reach $144 million annually by the year 1980, $205 million annually by the year 2000, and $296 million annually by the year 2020 if no flood control facilities were provided in addition to those in the July 1965 program. (Figure 5).

For major sub-basins, average annual damages range from $36.4 to $0.7 million dollars. The three sub-basins with the highest damages are: Wabash ($36.4 million), Kanawha ($7.0 million), and Scioto ($6.0 million). (Figure 6).

Utilizing the annual flood damage per capita relationship, the three sub-basins with the highest annual damages in dollars per capita are: Wabash ($11.63), Salt ($11.05), and Green ($9.63). The range is from $11.63 to $1.58 per capita with an Ohio Basin average of $5.83. (Figure 7).

FIGURE 4:
EFFECTIVENESS OF THE JULY 1965 FLOOD CONTROL AND FLOOD DAMAGE PREVENTION PLANS - OHIO RIVER BASIN

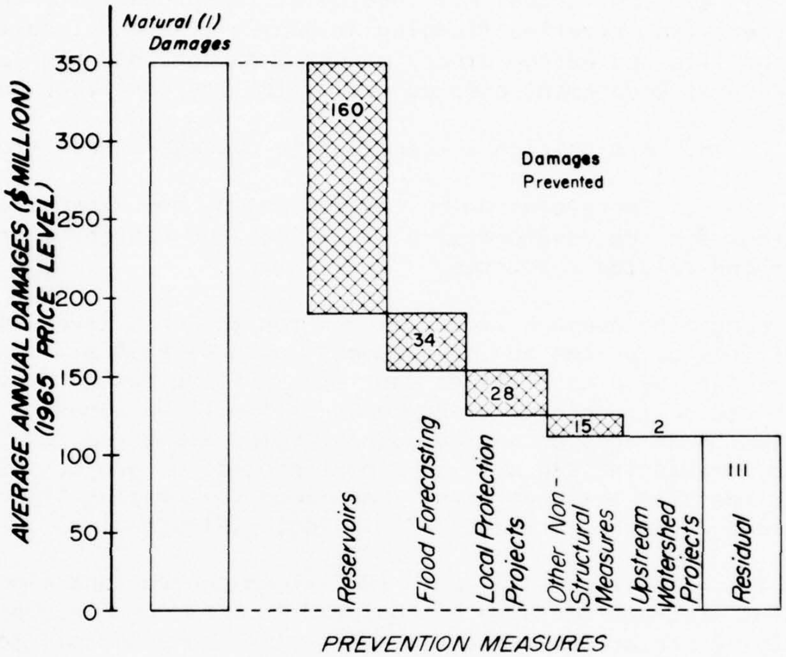
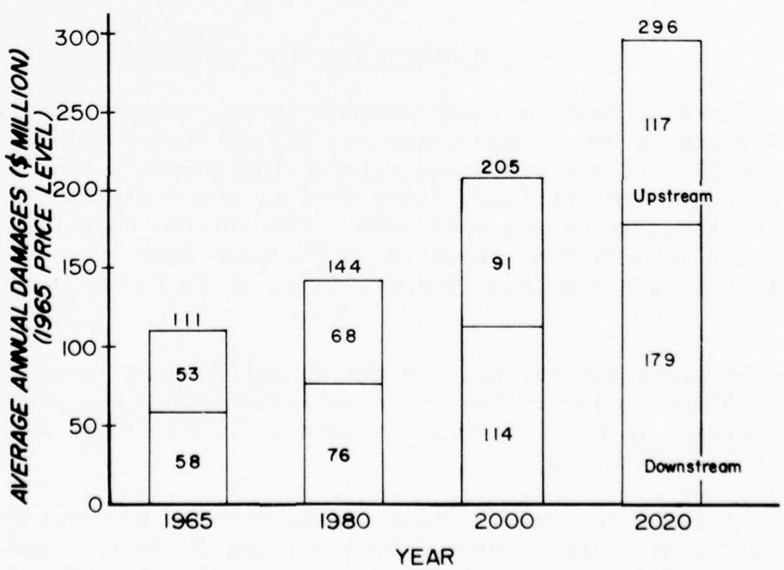


FIGURE 5:
JULY 1965 RESIDUAL AND PROJECTED (2) FLOOD DAMAGES - OHIO RIVER BASIN



NOTES:

(1) Natural damages with long time average hydrologic condition and 1965 development in flood plains.

(2) Damages are based on projected development in flood plains for years indicated.

OHIO RIVER BASIN COMPREHENSIVE SURVEY
CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION
APPENDIX M FIGURES 4-5

FIGURE 6:
AVERAGE ANNUAL FLOOD DAMAGES UNDER 1965 CONDITIONS OF DEVELOPMENT AND WITH PROJECTS IN JULY 1965 PLAN IN OPERATION.

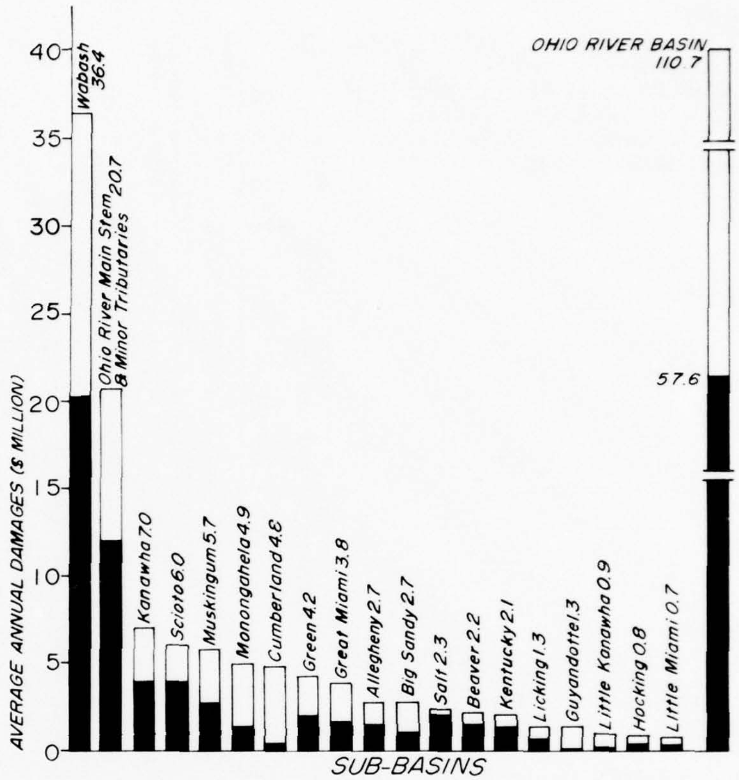
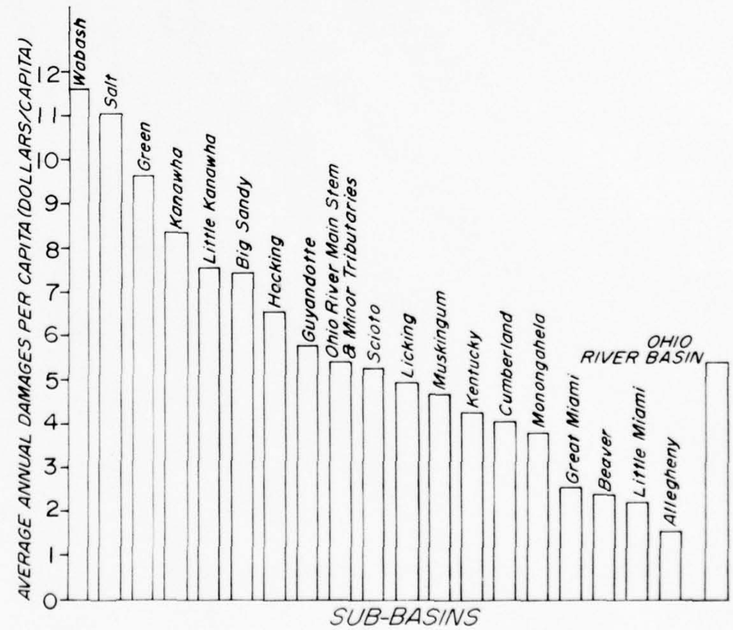


FIGURE 7:
AVERAGE ANNUAL FLOOD DAMAGES UNDER 1965 CONDITIONS OF DEVELOPMENT IN DOLLARS PER CAPITA - OHIO RIVER BASIN AND SUB-BASINS



NOTE. - PROJECTS IN JULY 1965 PLAN ASSUMED FULLY EFFECTIVE.

OHIO RIVER BASIN COMPREHENSIVE SURVEY	
CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION	
APPENDIX M	FIGURES: 6&7

FIGURE 8:
AVERAGE ANNUAL FLOOD DAMAGES UNDER 1965 CONDITIONS OF DEVELOPMENT IN DOLLARS PER SQUARE MILE OF DRAINAGE AREA - OHIO RIVER BASIN AND SUB-BASINS

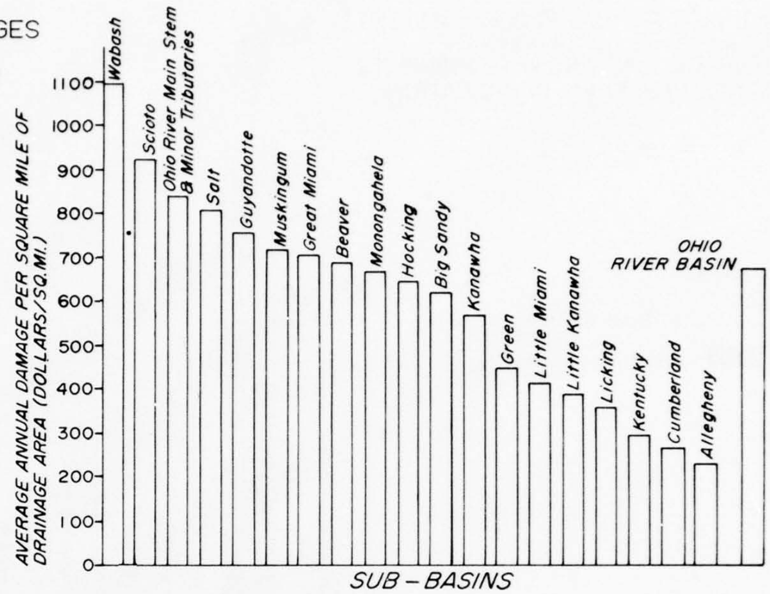
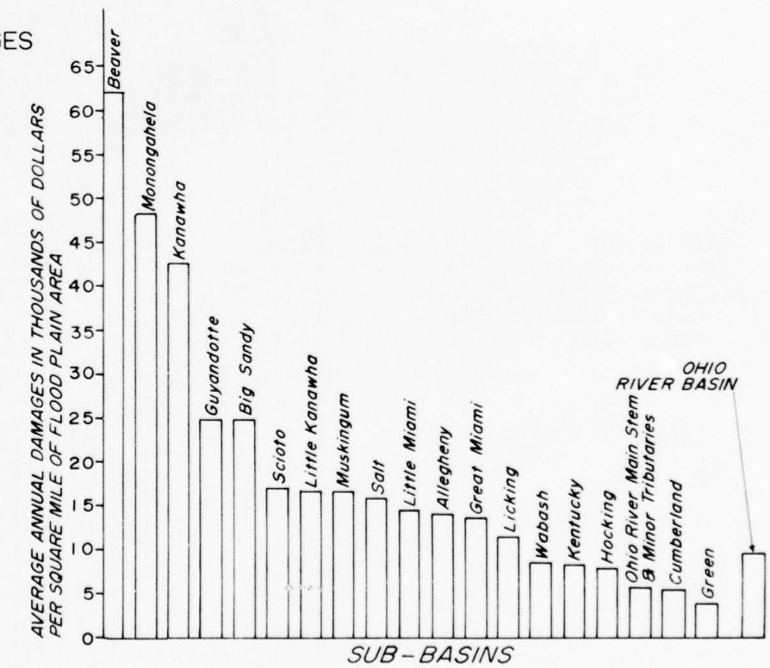


FIGURE 9:
AVERAGE ANNUAL FLOOD DAMAGES UNDER 1965 CONDITIONS OF DEVELOPMENT IN THOUSAND DOLLARS PER SQUARE MILE OF FLOOD PLAIN AREA - OHIO RIVER BASIN AND SUB-BASINS



NOTE.- PROJECTS IN JULY 1965 PLAN ASSUMED FULLY EFFECTIVE.

OHIO RIVER BASIN COMPREHENSIVE SURVEY
CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION
APPENDIX M FIGURES 8 & 9

FIGURE 8:
AVERAGE ANNUAL FLOOD DAMAGES UNDER 1965 CONDITIONS OF DEVELOPMENT IN DOLLARS PER SQUARE MILE OF DRAINAGE AREA – OHIO RIVER BASIN AND SUB-BASINS

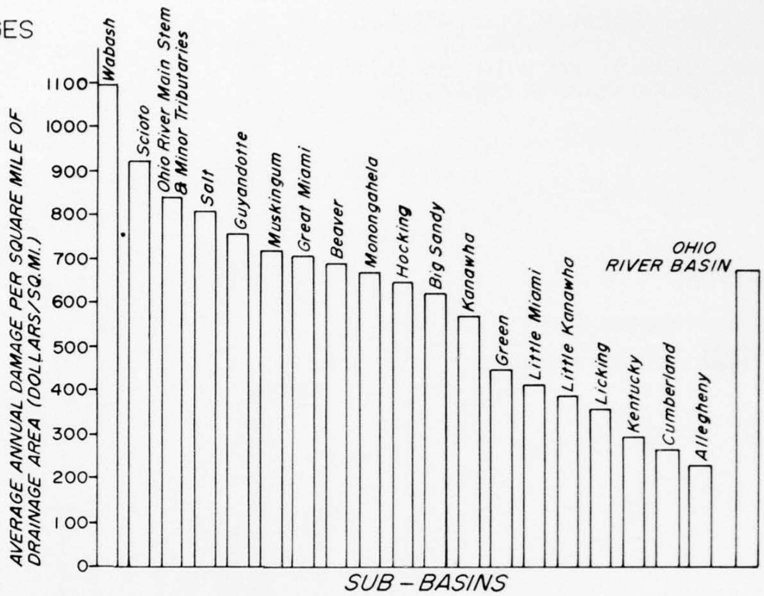
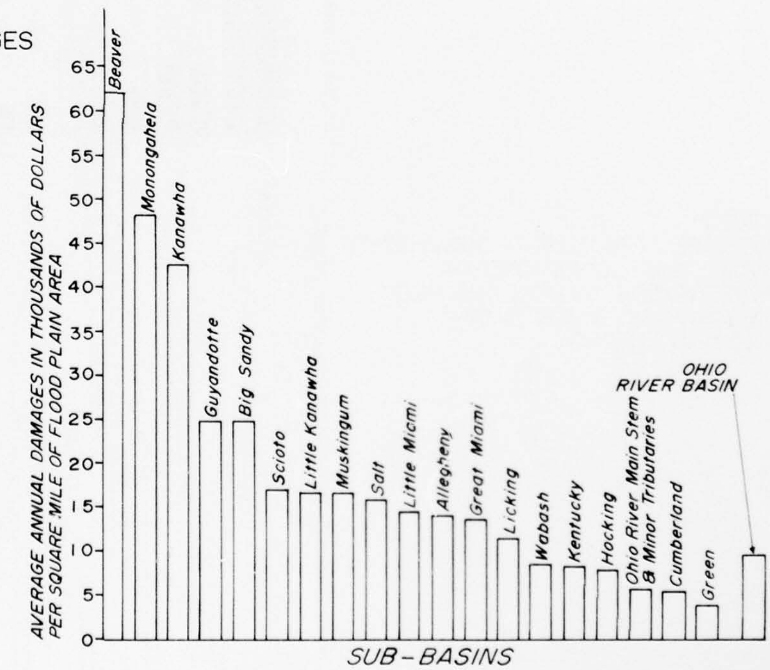


FIGURE 9:
AVERAGE ANNUAL FLOOD DAMAGES UNDER 1965 CONDITIONS OF DEVELOPMENT IN THOUSAND DOLLARS PER SQUARE MILE OF FLOOD PLAIN AREA – OHIO RIVER BASIN AND SUB-BASINS



NOTE.— PROJECTS IN JULY 1965 PLAN ASSUMED FULLY EFFECTIVE.

OHIO RIVER BASIN COMPREHENSIVE SURVEY	
CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION	
APPENDIX M	FIGURES 8 & 9

Residual average annual flood damages per square mile of drainage area range from $1,099 to $232 for major sub-basins. The Ohio River Basin average is $679. The three sub-basins with the highest annual damages per square mile of drainage area are: Wabash ($1,099), Scioto ($922), and Salt ($810). (Figure 8).

The residual annual damages per square mile of flood plain area range from $62,050 to $4,118. The Ohio River Basin average is $9,560. The three sub-basins with the highest annual damages per square mile of flood plain are: Beaver ($62,050), Monongahela ($48,372), and Kanawha ($42,648). (Figure 9).

The Wabash River Basin is first in total annual damages, annual damages per capita, and annual damages per square mile of total drainage area. The Beaver River Basin is highest in annual damages per square mile of flood plain area.

Flood problem areas are presented by 18 major sub-basins, minor tributaries to the Ohio River, and the Ohio River flood plain in Section II. There are 46 urban flood damage centers in the Basin with residual damages of $50,000 or more.

Of these, 35 centers have average annual damages in the range from $50,000 to $299,000 seven in the range from $300,000 to $599,000, two in the range from $600,000 to $999,000 and two over $1 million. (Table 3 and Figure 10).

Due to the nature and similarity of conditions of the potential upstream watershed areas, it was not practical to define specific locations in which flood damages were more critical than others. However, it was possible to determine flood damages per square mile. Those having a high potential (greater than $700 per square mile) are the Little Kanawha, Guyandotte, Monongahela, Cumberland and Wabash Sub-basins and Ohio River Minor Tributaries.

Potential Solutions to the Remaining Flood Problem

Potential solutions to the Ohio River Basin's flood problems include the development of control and prevention programs in all major sub-basins, which would include, in varying combinations and degrees, the construction of feasible Federal and non-Federal projects.

Flood control storage in multipurpose reservoirs are needed in all sub-basins. Such storage should lessen damages in their respective basin and contribute to the reduction of flood frequency and stages on the Ohio River. In addition, local protection projects could alleviate the flood problem at most of the major damage centers. Potential reservoirs and local protection projects exist in all sub-basins. There are 161 reservoirs and 95 major and 48 small local protection projects that have a potential for future construction. The 161 reservoirs would control 46,200 square miles of drainage area in addition to those reservoirs in the July 1965 plan, and provide over 15 million acre-feet of flood

Table 3

MAJOR URBAN FLOOD DAMAGE CENTERS[1]
(Centers with $50,000 or more in Annual Damages)

Average Annual Damage Range ($1,000)	Sub-Basin & Damage Center
Group #1 - 50-299	**Allegheny**
	Meadville, Pa, French Creek
	Dubois, Pa, Sandy Lick Creek
	Eldred, Pa, Allegheny River
	Monongahela
	Uniontown, Pa, Redstone and Coal Lick Creeks
	Beaver
	New Castle, Pa, Neshanock Creek
	Muskingum
	Mansfield, Ohio, Rocky Fork
	Zanesville, Ohio, Muskingum River
	Hocking
	Athens, Ohio, Hocking River
	Logan, Ohio, Hocking River
	Kanawha
	St. Albans - Nitro Area, W. Va, Kanawha River
	Marlinton, W. Va, Greenbrier River
	Big Sandy
	Martin, Ky, Beaver Creek
	Paintsville, Ky, Paint Creek
	Inez, Ky, Rockcastle Creek
	Grundy, W. Va, Levisa Fork
	Matewan, W. Va, Tug Fork
	Williamson, W. Va, Tug Fork
	Scioto
	La Rue, Ohio, Scioto River
	Kenton, Ohio, Scioto River
	Washington C.H., Ohio, Paint Creek
	Licking
	Salyersville, Ky, Licking River
	Falmouth, Ky, Licking River
	Kentucky
	Frankfort, Ky, Kentucky River[2]
	Wabash
	Columbus, Ind, Flatrock and Driftwood Rivers
	Marion, Ind, Mississinewa River
	Cumberland
	Pineville, Ky, Straight Creek[2]
	Harlan, Ky, Martins Fork and Clover Fork
	Barbourville, Ky, Cumberland River[2]
	Loyall, Baxter, Ky, Cumberland River
	Ohio River-Main Stem
	Steubenville, Ohio
	New Martinsville, W. Va
	Marietta, Ohio
	Dayton, Ky
	Aurora, Ind
	Evansville, Ind[2]
Group #2 - 300-599	**Allegheny**
	Jamestown-Falconer, N Y, Lake Chatauqua
	Monongahela
	Clarksburg, W. Va, West Fork River
	Weston, W. Va, West Fork River
	Kanawha
	Charlestown, W. Va, Kanawha River
	Kentucky
	Hazard, Ky, North Fork Kentucky River
	Ohio River-Main Stem
	Wheeling, W. Va
	Cincinnati, Ohio[2]
Group #3 - 600-999	**Scioto**
	Chillicothe, Ohio, Scioto River
	Wabash
	Indianapolis, Ind, White River[2]
Group #4 - Over 1,000	**Scioto**
	Columbus, Ohio, Scioto and Olentangy Rivers, Alum and Big Walnut Creeks
	Ohio River-Main Stem
	Pittsburgh Metropolitan Area, Pa

NOTES: (1) 1965 Price Level and Project Development
(2) Damage to areas outside existing local protection projects

LEGEND:

1. AVERAGE ANNUAL DAMAGES ($1,000)

- 50 to 299
- 300 to 599
- 600 to 999
- over 1,000

2. * DAMAGE TO AREAS OUTSIDE EXISTING LOCAL PROTECTION PROJECTS

NOTE: Projects in July 1965 plan assumed fully effective.

OHIO RIVER BASIN COMPREHENSIVE SURVEY

MAJOR URBAN FLOOD DAMAGE CENTERS

(AREAS SUSTAINING $50,000 OR MORE IN AVERAGE ANNUAL FLOOD DAMAGES)

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE 10

control storage. The 95 major and 48 small local protection projects contain about 400 miles of levees and walls and about 90 miles of channel improvements. The reservoirs and local protection projects are estimated to cost an additional $4.59 billion. (July 1965 constant dollars). These projects could reduce projected 1980, 2000 and 2020 downstream average annual damages by about 40, 60 and 70 percent respectively, while providing over an additional one million acres of downstream flood plain with flood protection and increasing the protection on 3.4 million acres presently receiving protection.

Many authorized local protection projects have not been constructed due to lack of local interests' inability to meet financial obligations connected with local sponsorship requirements. Potential solutions to those cases where local interests need financial aid to meet sponsorship requirements might be increased State participation in such projects and extension of present Federal loan authority for contributions.

In recent years, it has been the policy of several states to make investments in special water projects where particular needs are demonstrated and local financing appears difficult. In addition, the trend toward Federal-State river basin organizations holds possibilities for using these organizations for managing the financial aspect of water resource development.

Federal loan assistance available to local interests to pay for certain flood prevention or flood control programs, is restricted to loans through the Farmers Home Administration for Public Laws 534 and 566 projects, and loans to local governmental agencies in depressed areas through the Department of Commerce. Flood problems warrant extension of such loan authority to cover all cases of demonstrable financial need.

Watershed programs would reduce agricultural flood damages in upstream areas. In certain watersheds, flood damage prevention would be provided for rural communities. Potentially feasible projects exist in all sub-basins with the Wabash River Basin and Ohio River Minor Tributaries having the greatest potential. Potential watershed projects in the Salt, Licking, Green, Great Miami, Little Miami, and Scioto Sub-basins offer possibilities of reducing remaining damages in upstream areas by 65 to 76 percent. About 616 additional potential watershed projects appear to be feasible. Their locations and information on them are given in Section II. They could reduce existing upstream damages by $3.05 million annually or by 57 percent, leaving a residual of $22.7 million. Also, the opportunity to enhance land values by $14.7 million annually through more intensified and changed use would be possible on protected flood plains. These projects with a flood prevention cost of about $777.9 million would contain 3.5 million acre-feet of floodwater detention, 472,590 acre-feet of sediment storage and 6,328 miles of channel improvements. They would protect 1.88 million acres of flood plain. In addition to flood damage reductions in upstream areas, the combination of land treatment measures and retarding structures would reduce sedimentation in headwaters and downstream reaches. Generally,

the watershed projects are multiple-purpose and other functional needs are jointly served by their construction.

In upstream areas of marginal or infeasible structural control, land treatment measures offer a means of flood damage reduction. In addition, well-managed lands with good vegetative or forest cover would lessen the detrimental erosive forces of rain storms and also would reduce peak discharges of runoff and sedimentation. Detailed watershed studies have shown that reductions of from five to 10 percent in floodwater damages and from 10 to 30 percent in sediment deposition could be expected through proper land use, treatment and management. Another contribution is the extension of the useful life of major reservoirs and navigable channels through sediment reduction. Fire protection and grazing management are important considerations in maintaining a desired level of storm runoff and erosion reduction in the basin's 41 million acres of forest land. This is especially true in the eastern portion of the Ohio Basin wherein forests may extend over large areas such as the Guyandotte Basin which is more than 80 percent in forests.

Application of other appropriate non-structural measures such as flood plain management would help alleviate flood damage problems at most centers, particularly those susceptible to high intensive future development.

The delineation of flood-hazard areas in the basin is presently being carried out under the flood plain information program. These studies give basic data concerning flood potentials and conditions that are of much value in developing land use regulations and other preventative measures. To date about 43 studies have been authorized at a cost of about $830,000. The flood plain information program in the basin should be increased with special emphasis placed on the 46 major damage centers outlined in this report. A realistic flood plain information program in the Ohio River Basin to the year 2020 would consist of 700 or more additional studies at an estimated cost of about $18 million.

In summary, the total cost of the potential future flood control plan in upstream and downstream areas amounts to about $5.36 billion. The annual investment rate for this plan amounts to about $40 million in 1980, $103 million in 2000, and $157 million in 2020, as compared to the July 1965 annual investment rate of about $30 million. In addition to providing flood control, the plan will also create opportunity for low flow control, recreation and fish and wildlife. A summary of the potential future flood control plan is given in Section III.

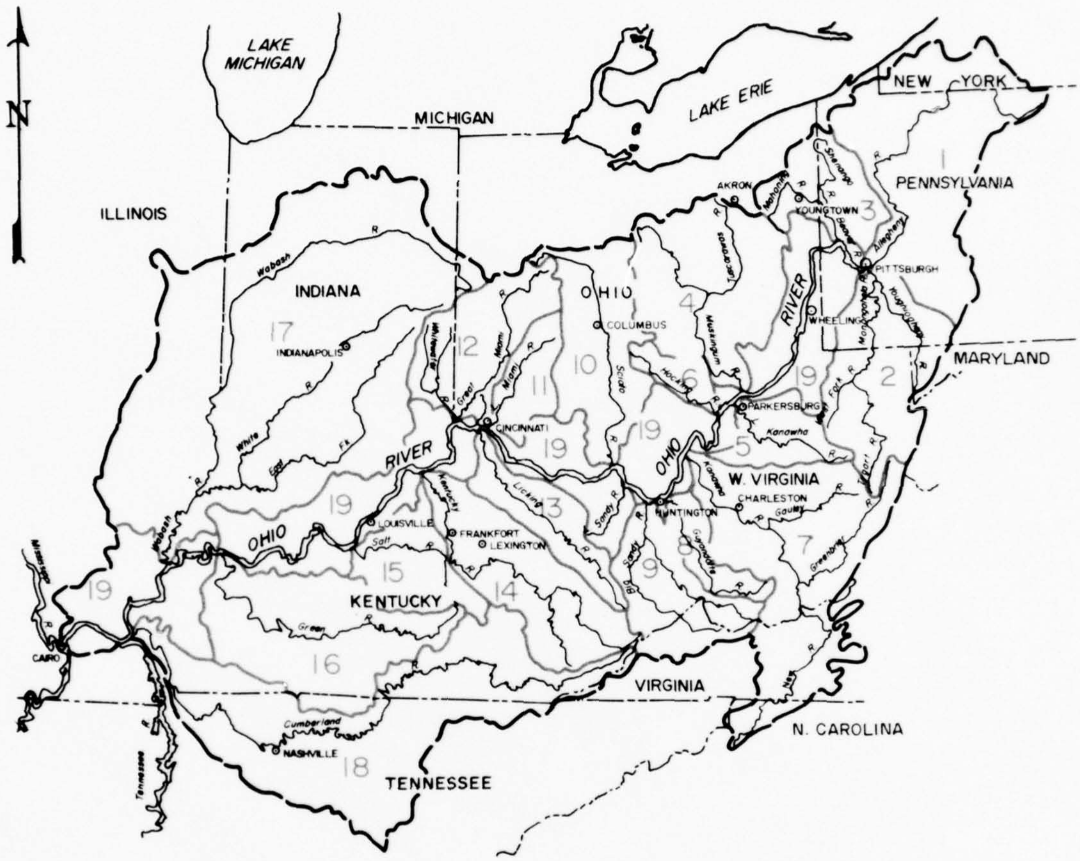
Land Management

Photo 12. Using land like this.....

Photo 13. .....Can prevent this.

SECTION II - OHIO RIVER SUBAREAS AND MAIN STEM FLOOD PROBLEMS AND POTENTIAL SOLUTIONS

The flood problem is widespread in the Ohio River Basin and the nature, magnitude and potential solutions are portrayed from this viewpoint. The following summaries on the 19 sub-areas and the Ohio River main stem, delineated on figure II, are intended to present not only the status of the current flood control and prevention programs, but also to identify remaining problem areas and indicate the potential solutions as part of the potential future flood control plan for the Ohio River Basin.



BASIN HYDROLOGIC SUBAREAS

1 ALLEGHENY RIVER BASIN
2 MONONGAHELA RIVER BASIN
3 BEAVER RIVER BASIN
4 MUSKINGUM RIVER BASIN
5 LITTLE KANAWHA RIVER BASIN
6 HOCKING RIVER BASIN
7 KANAWHA RIVER BASIN
8 GUYANDOTTE RIVER BASIN
9 BIG SANDY RIVER BASIN
10 SCIOTO RIVER BASIN
11 LITTLE MIAMI RIVER BASIN
12 GREAT MIAMI RIVER BASIN
13 LICKING RIVER BASIN
14 KENTUCKY RIVER BASIN
15 SALT RIVER BASIN
16 GREEN RIVER BASIN
17 WABASH RIVER BASIN
18 CUMBERLAND RIVER BASIN
19 OHIO RIVER MINOR TRIBUTARIES AND OHIO RIVER MAINSTEM

BASIN BOUNDARY

STATE BOUNDARY

HYDROLOGIC SUB-AREA BOUNDARY

OHIO RIVER BASIN COMPREHENSIVE SURVEY

OHIO RIVER BASIN
HYDROLOGIC SUBAREAS

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPDENDIX M FIGURE 11

1. Allegheny River Basin

The Allegheny River has its source in Potter County, northwestern Pennsylvania; then flows northwestward through McKean County, Pennsylvania, into southwestern New York; and then southward again into western Pennsylvania, joining the Monongahela River at Pittsburgh, Pennsylvania, to form the Ohio River. The Allegheny River Basin is situated in Pennsylvania and New York. The larger portion of the basin, which has a total area of about 11,700 square miles or about 62 percent of the total Ohio River headwater drainage above Pittsburgh, lies to the east of the main stem. Further to the east is the great Appalachian Mountain chain which protects the basin from most of the great Atlantic storms. The main river flows in a well-defined valley, having more or less precipitous sides, the eastern portion of the basin being, for the most part, rugged and drained by many tributaries. Mean annual runoff is about 23 inches, which is about 52 percent of the average annual precipitation, with the greatest runoff occurring during the months of January through April. Runoff from melting snow may occur at about the same time as runoff from rainfall. Consequently, snowmelt is a contributing factor to heavy runoff resulting in flood conditions.

The March 1936 flood is the maximum of record in the lower part of the basin, while the July 1942 flood attained the highest stage of record for most of the upper portion of the basin. Other floods are the maximum of record on some of the tributary streams. A recurrence of a composite(1) of the major floods in the basin without the intervening development of control works would cause $230.7 million in damages in downstream areas and inundate 30,800 acres. In contrast, a flood in downstream areas of a 100-year frequency modified by the July 1965 control program would cause losses about one-tenth as great and inundate about 14,300 acres. In upstream areas, the 100-year modified flood would cause $19.7 million in damages and inundate 88,950 acres. (Table AL-1).

The July 1965 Federal flood control plan in the basin consists of ten reservoirs, four upstream watershed projects, and 14 major and 11 small local protection projects. In addition, non-Federal interests have completed or have under construction nine local protection projects. (Table AL-2 and Figure AL-1). The ten reservoirs in the Federal plan control 45 percent of the drainage and contain over 1.7 million acre-feet of flood control storage. The July 1965 flood control plan will reduce natural average annual flood damages in downstream areas from $24.6 million to about $1.6 million. (Table AL-1). The four authorized upstream watershed projects, two in Pennsylvania and two in New York, cover an area of 492 square miles. Their structural measures will control 180 square miles and these projects consist of 31 miles of channel improvement and 27 structures which will provide storages of 26,298 acre-feet for floodwater and 1,241 acre-feet for sediment. The flood

(1) The composite flood as used throughout this appendix is represented by the flood profile of major record floods.

prevention cost of the projects amounts to $3.5 million, and they will reduce annual upstream damages by $308,000 and protect 12,096 acres of flood plain.

Major flood problem areas are located at the Jamestown-Falconer area, New York, and at Pittsburgh, Meadville, Dubois, and Eldred, Pennsylvania. The flood problem at Pittsburgh is discussed under the Ohio River main stem writeup at the end of this section. Other problem areas are at Allegany, New York, Millvale, Ridgway, and the area upstream of Johnstown, Pennsylvania; and at Russell, Pennsylvania, in the Conewango Creek watershed.

The problem at the Jamestown-Falconer area, is flooding from the Chadakoin River and highwater level on Lake Chautauqua. A project consisting of a gate-controlled diversion channel above Jamestown has been authorized. The project which was considered to be in advanced planning status for this appendix, has more recently become inactive because of lack of local interests to meet sponsorship requirements.

At Meadville on French Creek, the Union City, Muddy Creek and Woodcock Creek reservoirs in the July 1965 plan, will reduce average annual flood damages from $1.0 million to about $200,000. Additional reduction in damages will result when the channel improvement project by the Commonwealth of Pennsylvania is completed on Mill Run at Meadville.

Photo 14. Meadville, Pennsylvania during March 1956 flood.

The remaining damages will be mostly residential in nature and widespread along the affected area. A channel improvement project on French Creek could further reduce losses. However, such a project is not justified economically at this time and local people have not shown an interest in sponsoring the project.

The flood zones at and in the vicinity of Dubois are located along both banks of Sandy Lick Creek. This area is extensive, extending from Reynoldsville upstream to about the eastern limits of the basin. The developed area affected is situated in the creek reach from just below to just above the city limits of Dubois. A major channel improvement on Sandy Lick Creek at Dubois was authorized by the 1960 Flood Control Act. The plan provides for the improvement of Sandy Lick Creek by channel enlargement, and realinement. The project is considered to be a potential project for development.

Eldred is situated in McKean County on the right bank of the Allegheny River about 273 miles above its mouth. Barden Brook, a tributary stream, joins the Allegheny River at Eldred. The flood problem at Eldred is due to the location of a large part of the community on a relatively low flood plain which is subject to floods from storm concentrations over the relatively small drainage area above Eldred. Previous studies have indicated that the most suitable and comprehensive plan for flood protection at Eldred, would be a levee system along the Allegheny River with a limited channel improvement of Barden Brook. However, benefits from such a flood protection project, have been insufficient to justify the estimated expenditures required to provide the protection. At the request of local interests, a smaller flood control project consisting of clearing and straightening of Barden Brook, was completed in 1957 to protect Eldred against nuisance flooding.

Allegany suffers flood damages from Allegheny River flooding. A project to provide relief for this community was authorized by the 1946 Flood Control Act, but was later deferred for restudy because of lack of local interest. A restudy of reconnaissance scope of the authorized project is underway.

Millvale is located on Girtys Run, a right bank tributary of the Allegheny River. Flooding from Girtys Run in Millvale is from two sources: (a) backwater flooding from the Allegheny River at the mouth of Girtys Run; (b) flooding from Girtys Run due to the limited channel capacity and restrictive culverts in the stream throughout the Millvale reach. A study is underway to determine what measures are needed to alleviate the flood problem.

Due to flat slopes, meanders and low banks of the channel, the Clarion River at Ridgway cannot effectively carry off high discharges and often overflows into adjacent areas. The East Branch Clarion River Reservoir upstream and the Ridgway local protection project on Elk Creek presently provide a measure of protection for Ridgway; however, a flood problem still exists. A study is underway to determine the feasibility of construction of a channel improvement project for the Clarion River at Ridgway.

With the exception of localized protection by an upstream watershed project in the headwaters, the entire Conewango Creek watershed including Russell, Pennsylvania, has flood problems. A study of that portion of the watershed in New York indicated that present economic development is not sufficient to justify remedial action. For that portion of the watershed in Pennsylvania, a reconnaissance study is underway to determine the feasibility of remedial work in the flood plain area.

Ferndale, Riverside, the Bens Creek area, and the Maple Avenue section of Johnstown, Pennsylvania, are the principal flood zones in the Johnstown area upstream of the existing channel improvement. Each area has been settled in part of a flood plain. In studies underway, consideration is being given to solving flood problems above Johnstown by reservoirs on tributaries above the area.

The basin's downstream residual average annual damages of $1.6 million have been projected to increase about four times by the year 2020, assuming further control and prevention measures are not implemented. (Table AL-3). In order to reduce projected downstream flood damages in the Allegheny Basin, seven reservoir sites and four major and two small local protection projects have been selected to be included in a future flood control plan. (Table AL-4 and Figure AL-1).

Average annual damages of $1.2 million in upstream areas are projected to increase to $2.8 million by 2020 assuming further control and preventative measures in addition to the July 1965 plan are not implemented. (Table AL-3). The 19 potentially feasible upstream watershed projects, included in the potential future plan, consist of 19 miles of channel improvement and 112 floodwater retarding structures which could provide storages of 179,850 acre-feet for flood detention and 14,500 acre-feet for sediment. (Table AL-4 and Figure AL-1). These projects would cover an area of 3,746 square miles and their impoundments control 885 square miles, protect 41,837 acres of flood plain and provide an opportunity for enhancing land values through an increase in productivity estimated at $271,000 annually. The average annual flood damages occurring within these potential project watersheds are estimated at $824,000 with more than 85 percent attributable to urban developments. The damage per square mile of their watershed area is estimated at $220. The potentially feasible projects would reduce present average annual damages in upstream areas by $659,000.

As of September 1967, flood plain information studies are underway at Corry and Meadville, Pennsylvania. The study at Corry covers Hare Creek within the city limits and Bear Creek between Wayne Street and Confluence. At Meadville, the study area covers French and Cussewago Creeks. The upstream limit of the study on French Creek will be at the West Mead Township south boundary line.

Table AL-1

FLOOD PLAIN DATA - ALLEGHENY RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Composite Historical Flood(2) Area Inundated (Acres)	Composite Historical Flood(2) Damages ($1,000)
Agricultural Crop	18	Minor		106		163
Agricultural Non-Crop	Minor	Minor		Minor		Minor
Residential	7,713	752		9,284		60,541
Commercial	7,707	323		9,272		80,521
Industrial	5,788	189		6,936		65,814
Other(3)	3,370	301		4,032		23,635
TOTAL	24,596	1,565	14,260	29,630	30,800	230,674

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)
Crop and Pasture	205	66
Other Agriculture	30	14
Transportation Facilities	145	113
Urban	856	780
Sediment and Erosion	10	4
Indirect(4)	220	181
TOTAL	1,466	1,158

Category	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)
Crop		1,241
Non-Crop		272
Residential		6,460
Commercial and Industrial		9,520
Other(3)		2,193
TOTAL	88,950	19,686

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: March 1913, March 1936, July 1942, April 1947, April 1948, November 1950, October 1954, March 1956, July 1958, January 1959, May 1960.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruption to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table AL-2

JULY 1965 FLOOD CONTROL PLAN

ALLEGHENY RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage		Flood Control Storage		
							Major Flood Season		Conservation Season
					1,000 Ac Ft	Inches	1,000 Ac Ft	Inches	1,000 Ac Ft
Conemaugh River	C	F,R	1,351	274.0	4.0	0.1	270.0	3.7	270.0
Crooked Creek	C	F,R	277	93.9	4.5	0.3	89.4	6.1	89.4
E Br Clarion River	C	F,Q,R	72	84.3	1.0	0.3	38.7w[3]	10.0w	19.0s[3]
Loyalhanna	C	F,R	290	95.3	2.0	0.1	93.3	6.0	93.3
Mahoning Creek	C	F,R	340	74.2	4.5	0.3	69.7	3.8	69.7
Tionesta	C	F,R	478	133.4	7.8	0.3	125.6	4.9	125.6
Allegheny	UC	F,Q,R	2,180	1,180.0	24.0	0.2	940.0w	8.1w	607.0s
Union City	AP	F	222	47.6	-	-	47.6	4.1	47.6
Muddy Creek	AP	F	61	19.6	-	-	19.6	6.0	19.6
Woodcock Creek	AP	F,R	46	20.0	0.8	0.2	18.9w	5.8w	15.3s

B. UPSTREAM WATERSHED PROJECTS

Subbasin and Watershed Location	Purpose[4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage				Channel Improvements (Miles)
					Sediment (Ac Ft)	Floodwater (Ac Ft)	Other Uses (Ac Ft)	Total (Ac Ft)	
Mill Run, Pa	FP,F&WL	12.2	4	8.7	99	2,776	2,716	5,591	-
Sandy Creek, Pa	FP,F&WL	65.6	2	58.8	133	5,349	19,875	25,357	-
Conewango Creek, NY	FP,F&WL	297.0	13	68.3	657	10,616	1,700	12,973	30.9
Ischua Creek, NY	FP,F&WL,R	117.0	8	43.8	352	7,557	1,572	9,481	0.15

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles			
		Earth Levee	Concrete Flood Wall	Channel	Other
Bradford, Pa, Tunungwant Creek	C	0.1	-	6.9	Retaining wall - 1.7
Brookville, Pa, North Fork, Sandy Lick & Redbank Creeks	C	0.2	-	3.1	Pilot channel - 2.0+
Johnsonburg, Pa, East & West Branches Clarion River	C	0.3	0.1	0.9	Raise 800' RR & 360' highway, training wall
Johnstown, Pa, Stoney Creek, Conemaugh & Little Conemaugh Rivers	C	0.6	1.2	9.0	
Kittanning, Pa, (Part 1) Allegheny River	C	-	0.8	-	Bank revetment
Latrobe, Pa, (Part 1) Loyalhanna Creek	C	-	-	2.0	
Olean, NY, Allegheny River & Olean Creek	C	7.6	0.5	0.6	
Portville, NY, Allegheny River	C	4.3	0.1	-	
Punxsutawney, Pa, Mahoning Creek	C	1.9	0.5	3.6	
Reynoldsville, Pa, Sandy Lick Creek	C	-	-	2.2	
Ridgway, Pa, Elk Creek & Clarion River	C	-	-	1.1	Pilot channel - 1.2+
Latrobe, Pa, (Part 2) Loyalhanna Creek	UC	-	-	4.5	
Salamanca, NY, Allegheny River	AP	1.7	0.4	-	
Lake Chautauqua, Chadakoin River & Jamestown, NY	AP	-	-	0.8	3.4 mi. diversion channel, rehabilitate Warner Dam

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles			
		Earth Levee	Concrete Flood Wall	Channel	Other
Oil City, Pa, Oil Creek	C	0.4	-	-	
Portage, Pa, Trout Run	C	-	-	-	Concrete crib walls
Big Run, Pa, Mahoning Creek	C	-	-	2.6	
Sykesville, Pa, Stump Creek	C	-	-	1.2	
Wilmore, Pa, Little Conemaugh River	C	0.4	-	0.5	Concrete training wall
Tarentum, Pa, Bull Creek	C	-	-	1.0	

Snagging and Clearing Projects

Cochranton, Pa, French Creek	C
Eldred, Pa, Barden Brook	C
Etna, Pa, Pine Creek	C
Bradford, Pa, Tunungwant Creek & West Branch Tunungwant Creek	C
South Bradford, Pa, East Branch Tunungwant Creek	C

Table AL-2 (Cont'd)

JULY 1965 FLOOD CONTROL PLAN

ALLEGHENY RIVER BASIN

II. NON-FEDERAL

A. RESERVOIRS

NONE

B. LOCAL PROTECTION PROJECTS

Project Location	Status(5)	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Windber, Pa, Paint Creek & Seese Run	C	1.1	-	1.3	
Canadohta Lake, Pa, Mill Run	C	-	-	1.9	Water level regulation gates.
Tionesta, Pa, Council Run	C	-	-	-	310 ft., 60 in. corrugated metal pipe.
Brockway, Pa, Little Toby Creek	C	2.5	-	2.1	
Smethport, Pa, Marvin & Potato Creeks	C	-	-	0.5	
Coudersport, Pa, Allegheny River, & Mill Creek	C	0.6	-	1.0	
Warren, Pa, Glade Run	C	0.6	-	0.3	
Meadville, Pa, Mill Run	UC	-	-	0.2	
Warren, Pa, Indian Hollow Run	UC	-	-	0.2	1,180 ft., 72 in. conduit, debris basin, bridges.

NOTES: (1) Status: C - Completed UC - Under construction AP - Authorized - advanced planning

(2) Purpose: F - Flood control Q - Water quality R - Recreation

(3) w - Winter s - Summer

(4) Purpose FP - Flood prevention R - Recreation F&WL - Fish and wildlife development M&I - Municipal and industrial water supply

(5) Status of non-Federal projects as shown in Appendix J, "State Laws, Policies and Programs," Ohio River Basin Comprehensive Survey C - Completed UC - Under construction

Table AL-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

ALLEGHENY RIVER BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	1,565	2,292	3,915	6,657
Upstream	1,158	1,447	2,041	2,826
Total Basin	2,723	3,739	5,956	9,483

Table AL-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

ALLEGHENY RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Mill Creek	P	833	204.0	856.0
Clear Shade Creek	P	29	15.6	16.0
Cussewago Creek	P	91	24.5	43.7
North Branch	P	28	15.0	22.0
Shanksville	P	32	17.0	25.0
Sugar Creek	P	98	26.5	31.0
Redbank Creek	I	460	139.0	142.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
19	3,746	112	885	565,461	18,720	19

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Allegany, NY, Allegheny River	D	1.3	0.1	0.2
Dubois, Pa, Sandy Lick Creek	A	-	-	4.1
Millvale, Pa, Girtys Run (2)	P			
Russell, Pa, Conewango Creek (2)	P			

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Remarks
Ridgway, Pa, East Branch Clarion River	P	Under study by Corps of Engineers
Smethport, Pa, Marion Creek & Miller Brook	P	Channel Rehabilitation proposed by the Commonwealth of Pennsylvania

NOTES:

(1) July 1965 Status

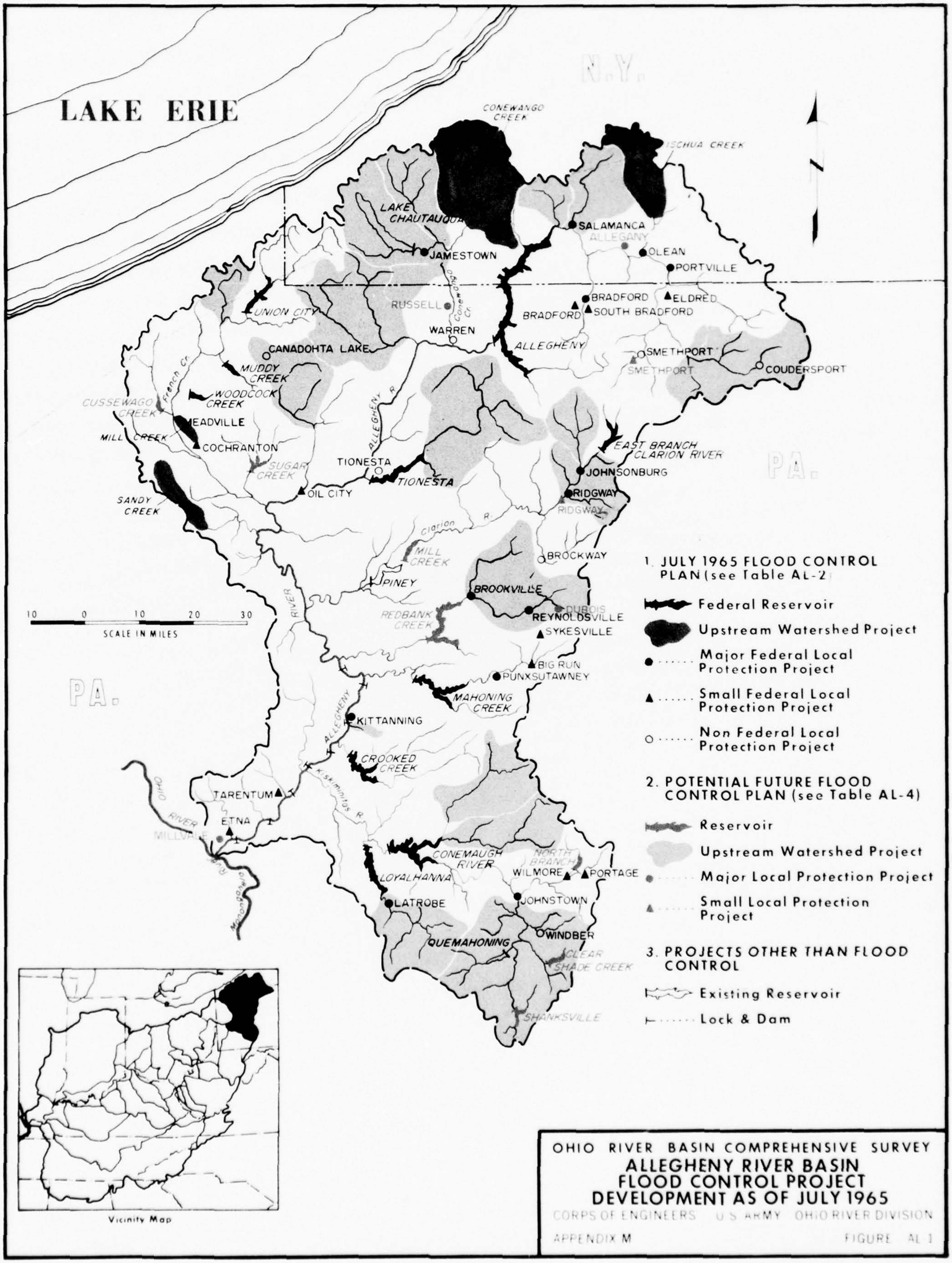
A - Authorized project - Active status

D - Authorized project - Deferred status

I - Authorized project - Inactive status

P - Potential project

(2) Project dimensions not defined at this time


LAKE ERIE
N.Y.
PA.
PA.
CONEWANGO CREEK
ISCHUA CREEK
LAKE CHAUTAUQUA
SALAMANCA
ALLEGANY
OLEAN
PORTVILLE
JAMESTOWN
BRADFORD
ELDRED
BRADFORD
SOUTH BRADFORD
RUSSELL
Conewango Cr.
WARREN
UNION CITY
CANADOHTA LAKE
ALLEGHENY
SMETHPORT
SMETHPORT
COUDERSPORT
MUDDY CREEK
WOODCOCK CREEK
CUSSEWAGO CREEK
French Cr.
MEADVILLE
MILL CREEK
COCHRANTON
ALLEGHENY R.
EAST BRANCH CLARION RIVER
SUGAR CREEK
TIONESTA
TIONESTA
JOHNSONBURG
OIL CITY
RIDGWAY
RIDGWAY
SANDY CREEK
Clarion R.
MILL CREEK
BROCKWAY
PINEY
BROOKVILLE
DUBOIS
REYNOLDSVILLE
REDBANK CREEK
SYKESVILLE
RIVER
BIG RUN
PUNXSUTAWNEY
MAHONING CREEK
ALLEGHENY
KITTANNING
CROOKED CREEK
Kiskiminitas R.
OHIO
TARENTUM
RIVER
ETNA
MILLVALE
Monongahela
CONEMAUGH RIVER
NORTH BRANCH
WILMORE
PORTAGE
LOYALHANNA
LATROBE
JOHNSTOWN
WINDBER
QUEMAHONING
CLEAR SHADE CREEK
SHANKSVILLE
10 0 10 20 30
SCALE IN MILES
1. JULY 1965 FLOOD CONTROL PLAN (see Table AL-2)
Federal Reservoir
Upstream Watershed Project
Major Federal Local Protection Project
Small Federal Local Protection Project
Non Federal Local Protection Project
2. POTENTIAL FUTURE FLOOD CONTROL PLAN (see Table AL-4)
Reservoir
Upstream Watershed Project
Major Local Protection Project
Small Local Protection Project
3. PROJECTS OTHER THAN FLOOD CONTROL
Existing Reservoir
Lock & Dam
Vicinity Map
OHIO RIVER BASIN COMPREHENSIVE SURVEY
ALLEGHENY RIVER BASIN
FLOOD CONTROL PROJECT
DEVELOPMENT AS OF JULY 1965
CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION
APPENDIX M
FIGURE AL 1

2. Monongahela River Basin

The Monongahela River, which drains about 7,400 square miles at its mouth, has its head at the confluence of the Tygart and West Fork Rivers near Fairmont, West Virginia. It flows in a northerly direction through north-central West Virginia and southwestern Pennsylvania where it joins the Allegheny River at Pittsburgh to form the Ohio River. The basin is situated in Pennsylvania, West Virginia and Maryland. In the upper reaches the Monongahela River is located within the Allegheny Mountains, where the slopes are steep and the flood plain is narrow. In the middle reaches, the flood plain is relatively narrow, while in the lower reaches there is a series of high level erosion terraces along the valley sides. Mean annual runoff from the basin is about 23 inches which is about 46 percent of the average annual precipitation. Greatest runoff months are usually January through April. Tributary stream runoff is fairly consistent, with the exception of the Cheat River which yields a higher rate of runoff because of usually heavier rainfall throughout the year and the long and extremely narrow shape and steepness of the basin. Runoff from melting snow does not seriously contribute to flood conditions because of generally higher temperatures which melt the snow before heavy rains occur.

The March 1936 flood is the maximum of record in most of the basin. A recurrence of a composite of it and other major record basin floods would inundate 13,000 acres and cause $49.6 million in damages to downstream areas if it were not for the intervening development of control works. This damage is about twice as great as that which would occur from the 100-year modified flood and the area under water would be about the same for both. In upstream areas, the 100-year modified flood would cause $25.1 million in damages and inundate 52,340 acres. (Table MO-1).

The July 1965 Federal flood control plan in the basin consists of two reservoirs, seven upstream watershed projects, and three major and seven small local protection projects. Non-Federal interests have constructed five local protection projects. (Table MO-2 and Figure MO-1). The two reservoirs included in the Federal flood control plan control 22 percent of the drainage area and contain 429,000 acre-feet of flood control storage. The seven upstream watershed projects cover an area of 124 square miles and their impoundments control 46 square miles. Their flood control cost amounts to $3.3 million and they will prevent $220,000 in annual upstream damages on about 2,300 acres.

The July 1965 flood control plan will reduce natural average annual flood damages in downstream areas from $9.5 million to about $1.4 million, and in upstream areas from $3.8 million to about $3.6 million. (Table MO-1). Major flood problem areas are located at Clarksburg and Weston, West Virginia, and at Pittsburgh and Uniontown, Pennsylvania. The flood problem at Pittsburgh is discussed under the Ohio River main stem writeup at the end of this section. Other problem areas are at Morgantown, Parsons, Hambleton, Hendricks, Wallace, and United States Forest Nursery, West Virginia, and at East Marianna and West Zollarsville, Pennsylvania.

The cities of Clarksburg and Weston are located on the West Fork River. Records indicate that the 1888 flood inundated about 450 acres at Clarksburg and about 175 acres at Weston. The Stonewall Jackson Reservoir included in the potential future flood control program would substantially alleviate the flood problem at Weston, but would not provide adequate flood protection for Clarksburg. During 1965 a review report of survey scope was underway to determine the advisability of improvements for flood control and allied purposes in the West Fork River Basin, particularly at Clarksburg and downstream.

Photo 15. February 1948 flood at Clarksburg, West Virginia

The city of Uniontown, located on Redstone and Coal Lick Creeks in Fayette County, comprises about 1,187 acres of which about 61 acres are subject to flooding. Redstone Creek, through its course at Uniontown, is bordered by numerous residences, industrial and manufacturing plants, railroads, and highways. As a result of previous studies, a local protection project at Uniontown was authorized by the 1948 Flood Control Act. The project, consisting of channel improvement of Redstone Creek, will protect the community against discharges up to 2,000 cubic feet per second on that stream. Damages resulting from higher discharges will also be reduced. However, because of current lack of economic feasibility, construction of the project has been deferred.

Flooding occurs at Morgantown because of the inadequate channel capacity of Deckers Creek which bisects the town. Based on the extent of flooding in August 1956, the flooded area within the corporate limits

of Morgantown totals 75 acres. A recent survey scope study concluded that a channel improvement project on Deckers Creek was the best suited economically feasible plan to provide flood protection for Morgantown. However, local interests indicated they were unable to meet local sponsorship requirements.

The city of Parsons, the towns of Hambleton and Hendricks, and the United States Forest Service Experiment Station are subject to damaging floods periodically. In a study underway, the plan of improvement proposed consists of channel deepening and widening and deflection dikes for the city of Parsons, and deflection dikes for the Forest Service Experiment Station and the towns of Hambleton and Hendricks.

The villages of East Marianna and West Zollarsville, and the town of Wallace lie in a relatively narrow section of the valley above Tenmile and Little Tenmile Creeks, respectively. Due to restrictive channel sections, these two streams cannot effectively carry high flood discharges. In studies currently underway, channel improvements have been proposed to alleviate flood problems at these locations.

Average annual downstream damages of $1.4 million are expected to increase about four times by the year 2020, assuming further control and prevention measures are not implemented. (Table MO-3). In order to reduce projected downstream damages, eight reservoir sites and three major and six small local protection projects have been selected to be included in a future flood control plan. (Table MO-4 and Figure MO-1).

Average Annual damages of $3.6 million in upstream areas are expected to increase to about $7.9 million by 2020. (Table MO-3). Structural measures supplementing land treatment have been found to be potentially feasible in 18 additional upstream watersheds. (Table MO-4 and Figure MO-1). They would contain 10 miles of channel improvements and 148 retarding structures controlling 622 square miles of drainage area and could provide storages of 111,300 acre-feet for floodwater detention and 13,000 acre-feet for sediment. The average annual flood damages occurring within these potential project watersheds are estimated at $2.1 million. Damages are attributable as follows: two percent to agriculture, eight to transportation facilities, and 90 to urban developments. The damage per square mile of their watershed area is estimated at $1,129. The potentially feasible projects would reduce average annual damages in upstream areas by $1.7 million. These would protect about 15,000 acres of flood plain and enable increased agricultural production in some areas.

In addition to these potential projects, the Commonwealth of Pennsylvania has proposed local protection projects at Meyersdale, Garrett, and Rockwood. (Table MO-4 and Figure MO-1).

As of September 1967, a flood plain information study has been completed in the Youghiogheny sub-basin. It covers Jack's Run from Greensburg to its confluence with Sewickley Creek and Sewickley Creek from Armbrust to the south boundary of Hempfield Township. Also, a similar study is underway of the Pigeon Creek flood plain within the boundary of Bentleyville Borough and Fallowfield Township, Washington County, Pennsylvania.

Table MO-1

FLOOD PLAIN DATA - MONONGAHELA RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Average Annual Damages ($1,000)			100 Year Modified Flood(1)		Composite Historical Flood(2)	
Category	Natural	Modified(1)	Area Inundated (Acres)	Damages ($1,000)	Area Inundated (Acres)	Damages ($1,000)
Agricultural Crop	38	Minor		114		166
Agricultural Non-Crop	Minor	Minor		Minor		Minor
Residential	2,409	568		5,579		11,354
Commercial	1,342	240		3,097		6,226
Industrial	4,129	265		9,554		24,392
Other(3)	1,611	284		3,734		7,497
TOTAL	9,529	1,357	12,140	22,078	13,030	49,636

B. UPSTREAM AREAS

Average Annual Damages ($1,000)		
Category	Natural	Modified(1)
Crop and Pasture	112	85
Other Agriculture	36	35
Transportation Facilities	331	308
Urban	2,950	2,817
Sediment and Erosion	7	6
Indirect(4)	370	333
TOTAL	3,806	3,584

100 Year Modified Flood(1)		
Category	Area Inundated (Acres)	Damages ($1,000)
Crop		658
Non-Crop		273
Residential		9,478
Commercial and Industrial		12,257
Other		2,422
TOTAL	52,340	25,088

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: March 1918, February 1932, March 1936, June 1941, July 1947, June 1950, June 1951, October 1954, November 1955, August 1956, March 1963.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruption to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table MO-2

JULY 1965 FLOOD CONTROL PLAN

MONONGAHELA RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Purpose (2)	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage: 1,000 Ac Ft	Minimum Storage: Inches	Flood Control Storage — Major Flood Season: 1,000 Ac Ft	Flood Control Storage — Major Flood Season: Inches	Flood Control Storage — Conservation Season: 1,000 Ac Ft
Tygart	C	F,N,R	1,184	287.7	9.7	0.2	278.0w (3)	4.4	178.1s (3)
Youghiogheny	C	F,Q,R	434	254.0	5.2	0.2	151.0w	6.5	99.5

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose (4)	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Little Youghiogheny, Md	FP	41.0	6	14.4	223	3,003	-	3,226	1.6
Dunlap Creek, Pa	FP,F&WL	16.5	4	8.6	151	1,227	780	2,158	.2
Polk Creek, W Va	FP	11.4	8	6.6	253	1,528	-	1,781	-
Upper Deckers Creek, W Va	FP	31.1	5	14.6	389	1,651	-	2,040	7.2
Salem Fork, W Va	FP	8.3	7	2.1	27	355	-	382	-
Shooks Run, W Va	FP	3.0	-	-	-	-	-	-	.7
Peck's Run, W Va	FP	12.8	-	-	-	-	-	-	6.0

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Elkins, W Va, Tygart River	C	0.7	-	0.3	Diversion & Protection Dikes
Turtle Creek, Pa	UC	-	-	7.4	Debris Basins & Drop Structures
Buckhannon, W Va, Buckhannon River	UC	-	-	4.6	

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Granville, Pa, Pike Run & Gorby Run	C	-	-	0.9
Friendsville, Md, Bear Creek	C	-	-	0.6
Snagging and Clearing Projects				
Fairbank, Pa, Dunlap Creek and Saltlick Run	C			
Weston, W Va, Polk Creek	C			
Weston, W Va, Stonecoal Creek	C			
Stonewood & Nutter Fort, W Va, Elk Creek	C			
Wyatt, W Va, Bingamon Creek	C			

II. NON-FEDERAL

A. RESERVOIRS

None

B. LOCAL PROTECTION PROJECTS

Project Location	Status (5)	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Greensburg, Pa, Jacks Run	C	0.5	-	3.0	
Jeannette, Pa, Brush Creek	C	0.6	-	3.2	
Jeannette, Pa, Bull Run Dam	C	-	-	-	Increased height of earthfill dam, 5 ft, trashrack outlet structures
Rockwood, Pa, Casselman River & Coxes Creek	UC	0.3	-	0.2	
Confluence, Pa, Youghiogheny River, Casselman River, & Laurel Hill Creek	UC	1.1	-	1.0	

NOTES: (1) July 1965 Status: C - Completed UC - Under construction

(2) Purpose: F - Flood control R - Recreation Q - Water quality

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention F&WL - Fish and wildlife development

(5) Status of non-Federal projects as shown in Appendix J, "State Laws, Policies and Programs," Ohio River Basin Comprehensive Survey
C - Completed UC - Under construction

Table MO-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

MONONGAHELA RIVER BASIN

Area Location	Average Annual Damages ($1,000)			
	Residual	Projected		
	1965	1980	2000	2020
Downstream	1,357	2,020	3,483	5,617
Upstream	3,584	4,445	5,993	7,916
Total Basin	4,941	6,465	9,476	13,533

Table MO-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

MONONGAHELA RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Laurel Hill Creek	P	115	60.7	62.0
Rowlesburg	P	936	299.6	831.7
Stonewall Jackson	P	102	38.0	75.2
Big Sandy Creek	P	97	84.0	87.0
Crellin	P	56	94.0	95.0
Elk Creek	P	84	82.0	129.0
Middle Fork River	P	137	220.0	228.0
Wymer	P	44	73.0	115.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
18	1,896	148	622	279,423	9,995	10

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Clarksburg, W Va West Fork River[2]	P			
Morgantown, W Va, Deckers Creek	P	-	-	2.4
Uniontown, Pa, Redstone Creek	D	-	-	2.7

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Remarks
Parsons, W Va, Shavers Fork & Black Fork	P	Channel improvement, earth levee
Hambleton, W Va, Black Fork	P	Earth levee
Hendricks, W Va, Black Fork & Blackwater River	P	Earth levee
Wallace, W Va, Little Ten Mile Creek	P	Channel improvement
Marianna, Pa, Ten Mile Cr	P	Channel improvement
U.S. Forest Nursery, W Va, Black Fork	P	Earth levee
Meyersdale, Pa, Casselman River & Flaugherty Creek[3]	P	Concrete channel, earth levee
Garrett, Pa, Casselman River & Buffalo Creek[3]	P	Earth levees, channel rehabilitation
Rockwood, Pa, Casselman River[3]	P	Pressure conduit

NOTES:

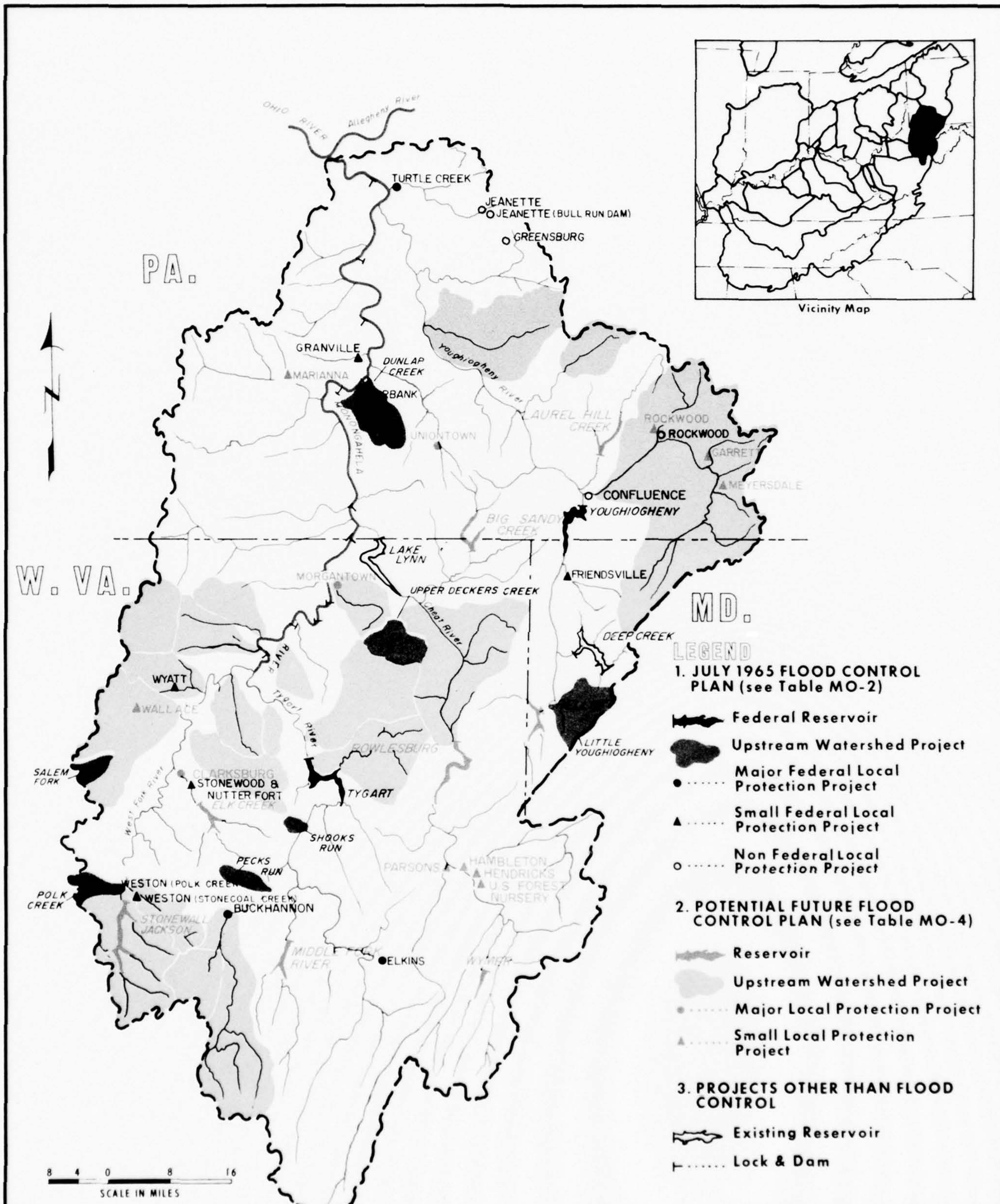
(1) July 1965 Status

D - Authorized project - Deferred Status

P - Potential project

(2) Project dimensions not defined at this time

(3) Proposed by the Commonwealth of Pennsylvania



OHIO RIVER BASIN COMPREHENSIVE SURVEY

MONONGAHELA RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE MO-1

3. Beaver River Basin

The Beaver River is formed by the confluence of the Shenango and Mahoning Rivers in western Pennsylvania, near the Ohio State line, flows south 21 miles, and enters Ohio River at Rochester, Pennsylvania, 956 miles above the mouth. The basin is situated in Ohio and Pennsylvania with a total drainage area of about 3,130 square miles. Topography of the north and west sections of the basin is glaciated, while the southeastern part is unglaciated, rugged, and dissected by the tributary streams. Mean annual runoff is about 15 inches which is about 40 percent of the average annual precipitation.

The March 1913 flood is the maximum of record for most areas in the basin. A recurrence of composite of record floods, including the March 1913, would cause about $25.2 million in damages to downstream areas and inundate about 4,500 acres. This is slightly greater than the damages that would occur from a modified 100-year flood and its overflow would be about twice as great. In upstream areas, the 100-year modified flood would cause $10.2 million in damages and inundate 17,940 acres. (Table BE-1).

The July 1965 Federal flood control plan in the basin consists of four reservoirs, two upstream watershed projects, and two major local protection projects. Non-Federal interests have completed one local protection project involving channel rehabilitation and two reservoirs. (Table BE-2 and Figure BE-1). The four reservoirs in the existing Federal plan control 32 percent of the drainage area, and contain over 300,000 acre-feet of flood control storage. The basin's two upstream watershed projects in Mercer and Crawford Counties, Pennsylvania, (the Saul-Mathay project in Mercer County, has been completed), cover an area of 120 square miles and their impoundments will control 64 square miles of drainage area. The flood prevention cost amounts to $1.7 million and they will prevent $79,000 in annual upstream damages on 540 acres of flood plain.

The July 1965 flood control plan will reduce average annual flood damages in downstream areas from $14.7 million to about $1.5 million, and in upstream areas from $781,000 to about $702,000. (Table BE-1). A major flood problem area is located at New Castle, Pennsylvania, along Neshannock Creek and along Connoquenessing Creek below Butler, Pennsylvania, a flood problem of lesser magnitude exists.

The flood problem at New Castle results in $104,000 average annual damages mostly to commercial and residential developments. An economic feasibility study for a channel improvement project is underway.

Along Connoquenessing Creek below Butler approximately eight communities suffer damage from flooding, with recent major floods occurring in October 1954, and March 1964. In addition, nuisance flooding of these areas occurs annually. A review report of survey scope is underway of the area.

Average annual downstream damages of $1.5 million are projected to increase to $5.4 million by the year 2020. (Table BE-3). In order to reduce these projected damages in downstream areas, two reservoirs and two major local protection projects have been included in the potential future flood control plan. (Table BE-4 and Figure BE-1). One of the two reservoirs in the future plan is the Grand River Reservoir, in the Grand River Basin, adjacent and to the north of the Mahoning Basin. The Grand Basin drains into Lake Erie. Flood flows from an 898 square mile drainage area of the Mahoning River, a tributary of the Beaver River, would be diverted to the Grand River Reservoir during flood periods and later released into the Mahoning River for other uses. This diversion of flood flows would be a significant factor in controlling floods on the Mahoning, Beaver, and Ohio Rivers.

Average annual damages of $702,000 in upstream areas are expected to increase to $1.4 million by 2020. (Table BE-3). Structural measures supplementing land treatment have been found potentially feasible in five additional upstream watersheds. (Table BE-4 and Figure BE-1). They would contain eight miles of channel improvement and 32 retarding structures, which could provide storages of 43,430 acre-feet for water detention and 4,250 acre-feet for sediment. The impoundments would control runoff from 253 square miles of drainage area, or about 28 percent of the total area in potential upstream watersheds. The average annual flood damages occurring within these potential project watersheds are estimated at $277,500, attributable as follows: 0.5 percent, agriculture; 17 percent, transportation facilities; and 82.5 percent, urban developments. The damage per square mile of their watershed area is estimated at $307. The potentially feasible projects are estimated to reduce average annual damages in upstream areas by $222,000. These would protect more than 8,500 acres of flood plain and provide an opportunity to enhance land values through an annual increase in productivity of about $96,000.

As of September 1967, flood plain information studies have been completed on the Neshannock Creek from New Castle, upstream to the Lawrence County line on the Shenango and Mahoning Rivers, from New Castle to the Lawrence County line and on Mosquito Creek from Mosquito Creek Reservoir to its confluence with the Mahoning River.

Table BE-1

FLOOD PLAIN DATA - BEAVER RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

	Average Annual Damages ($1,000)		100 Year Modified Flood(1)		Composite Historical Flood(2)	
Category	Natural	Modified(1)	Area Inundated (Acres)	Damages ($1,000)	Area Inundated (Acres)	Damages ($1,000)
Agricultural Crop	Minor	Minor		Minor		Minor
Agricultural Non-Crop	Minor	Minor		Minor		Minor
Residential	1,274	54		1,175		2,167
Commercial	1,635	82		1,680		2,822
Industrial	9,438	1,140		15,683		16,129
Other(3)	2,391	206		3,040		4,082
TOTAL	14,738	1,482	1,850	21,578	4,536	25,200

B. UPSTREAM AREAS

	Average Annual Damages ($1,000)	
Category	Natural	Modified(1)
Crop and Pasture	11	10
Other Agriculture	9	9
Transportation Facilities	110	109
Urban	547	484
Sediment and Erosion	0	0
Indirect (4)	104	90
TOTAL	781	702

	100 Year Modified Flood(1)	
Category	Area Inundated (Acres)	Damages ($1,000)
Crop		161
Non-Crop		146
Residential		2,686
Commercial and Industrial		5,504
Other(3)		1,752
TOTAL	17,940	10,249

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: March 1913, July 1956, January 1959.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table BE-2

JULY 1965 FLOOD CONTROL PLAN

BEAVER RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Purpose (2)	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Berlin	C	F,M,Q	249	91.2	1.8	0.1	55.8w (3)	4.2w	32.8s (3)
Mosquito Creek	C	F,M,Q,R	97	104.1	2.0	0.4	33.0w	6.4w	21.7s
Shenango	UC	F,Q,R	589	192.4	11.5	0.5	180.9w	7.9w	151.0s
West Branch	UC	F,Q,R	81	78.7	3.8	0.9	33.2w	7.7w	22.0s

B. UPSTREAM WATERSHED PROJECTS

Subbasin and Watershed Project	Purpose (4)	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Sediment (Ac Ft)	Floodwater (Ac Ft)	Other Uses (Ac Ft)	Total (Ac Ft)
Saul-Mathay, Pa	FP	6.1	2	3.0	29	585	-	614
Little Shenango River, Pa	FP,R	113.7	8	60.8	252	7,246	2,505	10,003

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Butler, Pa, Connoquenessing Creek	UC	-	-	4.0
Youngstown, Ohio, Crab Creek	AP	-	-	2.4

D. SMALL LOCAL PROTECTION PROJECTS

None

II. NON-FEDERAL

A. RESERVOIRS

Reservoir	Status (5)	Purpose (2)	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1,000 Ac Ft)	Total Storage (1,000 Ac Ft)
Pymatuning	C	F,Q,R	158	84.4	217.8
Milton(6)	C	F,Q	27(7)	5.5	29.8

B. LOCAL PROTECTION PROJECTS

Project Location	Status (5)	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
West Middlesex, Hogback Run	C	-	-	1.4

NOTES:
(1) July 1965 Status C - Completed AP - Authorized - advanced planning UC - Under construction

(2) Purpose F - Flood control M - Water supply R - Recreation
Q - Water quality

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention R - Recreation M&I - Municipal and industrial water supply
F&WL - Fish and wildlife development

(5) Status of non-Federal Projects as shown in Appendix J, "State Laws, Policies and Programs," Ohio River Basin Comprehensive Survey
C - Completed

(6) Milton Reservoir operated in coordination with the Federal Berlin Reservoir for flood control and low-water regulation

(7) Net drainage area below Berlin Reservoir

Table BE-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

BEAVER RIVER BASIN

	Average Annual Damages ($1,000)			
	Residual	Projected		
Area Location	1965	1980	2000	2020
Downstream	1,482	2,050	3,307	5,375
Upstream	702	821	1,063	1,393
Total Basin	2,184	2,871	4,370	6,768

Table BE-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

BEAVER RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65(1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1,000 Ac Ft)	Total Storage (1,000 Ac Ft)
Eagle Creek	I	95	33	121
Grand River(3)	P	1,002	405	2,207

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
5	905	32	253	92,476	4,432	8

C. MAJOR LOCAL PROTECTION PROJECTS

		Type of Project and Length in Miles		
Project Location	Jul 65(1) Status	Earth Levee	Concrete Flood Wall	Channel
Connoquenessing Creek(2) below Butler, Pa	P			
New Castle, Pa(2) Neshannock Creek	P			

D. SMALL LOCAL PROTECTION PROJECTS

None defined at present.

NOTES:

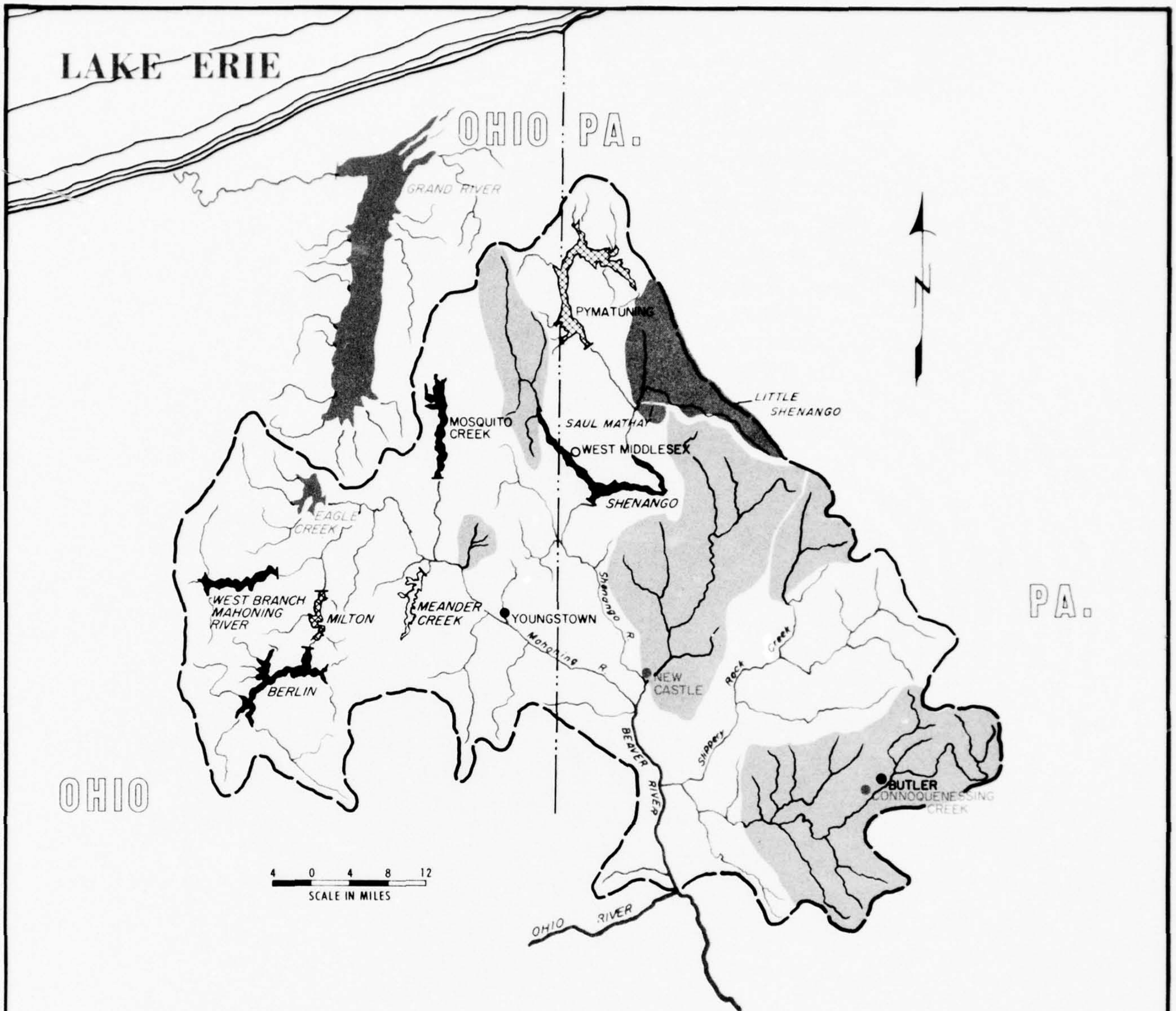
(1) July 1965 Status

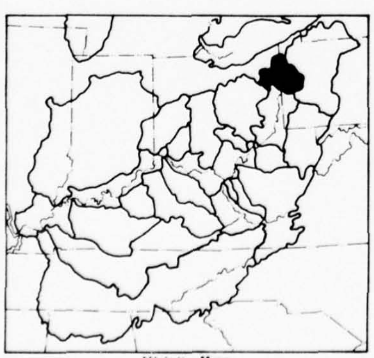
I - Authorized project - inactive status

P - Potential Project

(2) Project dimensions not defined at this time

(3) In Grand River Basin, Lake Erie drainage





Vicinity Map

LEGEND

1. JULY 1965 FLOOD CONTROL PLAN (see Table BE-2)

- Federal Reservoir
- Non Federal Reservoir
- Upstream Watershed Project
- Major Federal Local Protection Project
- Non Federal Local Protection Project

2. POTENTIAL FUTURE FLOOD CONTROL PLAN (see Table BE-4)

- Reservoir
- Upstream Watershed Project
- Major Local Protection Project

3. PROJECTS OTHER THAN FLOOD CONTROL

- Existing Reservoir

OHIO RIVER BASIN COMPREHENSIVE SURVEY

BEAVER RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE BE-1

4. Muskingum River Basin

The Muskingum River which lies wholly within the State of Ohio and drains approximately 8,040 square miles, is formed by the confluence of the Walhonding and the Tuscarawas River at Coshocton, flows approximately 112 miles in a southerly direction and joins the Ohio River at Marietta 809 miles above the mouth. Except for sections of the unglaciated portion of the basin, the flood plain of the main stem and major tributaries is relatively wide and fertile. The mean annual runoff for the basin is about 13.3 inches, with maximum and minimum values of 21.5 and 4.9 inches, respectively.

With few minor exceptions, the maximum flood of record in the Muskingum Basin occurred in March 1913. This flood caused the loss of 11 lives in the basin and estimated total direct damages amounting to about $9 million at 1913 price level. Today a similar flood would cause damages nine or ten times as great, if it were not for the present system of flood control reservoirs.

The July 1965 Federal flood control plan in the basin consists of 16 reservoirs, one upstream watershed project, and four major and two small local protection projects. (Table MU-2 and Figure MU-1). Fourteen of the reservoirs were constructed between 1934 and 1938 by the Corps of Engineers for the Muskingum Watershed Conservancy District, using funds provided by the Federal Government and the Conservancy District. Subsequent legislation incorporated them into the flood control plan for the Ohio River Basin. The conservancy district, a political subdivision of Ohio, has the necessary powers of eminent domain, raising of funds by special assessment and authority to enter into contracts with the State and Federal governments.

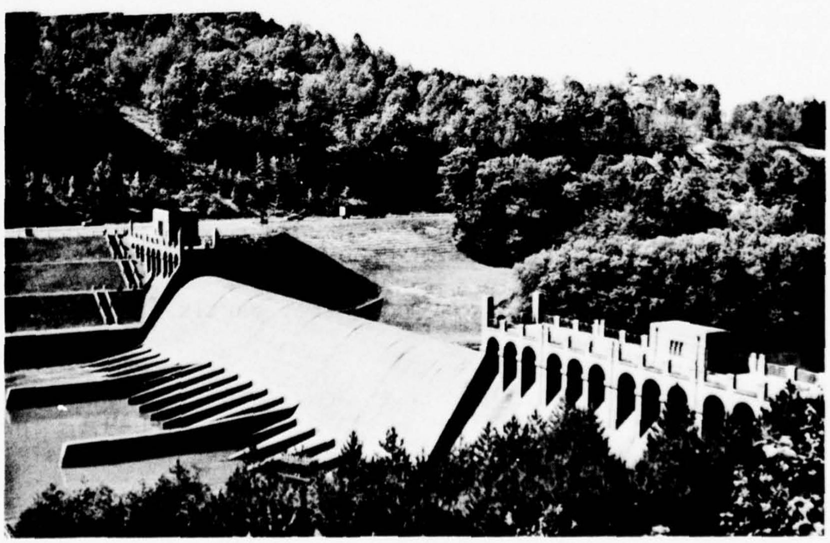


Photo 16. Dover Dam in the Muskingum Reservoir System

The Chippewa Creek Watershed in Medina and Wayne Counties is the only authorized watershed project in the basin. The project encompasses 188 square miles, of which 39 are controlled by nine floodwater retarding structures. These structures and 33 miles of channel improvement provide protection to 10,300 acres of flood plain. The flood prevention cost of the project amounts to $2 million and it will prevent $98,000 in annual upstream damages.

In addition to the Federal projects, the State of Ohio has under construction a multipurpose, flood control, water supply, and recreation reservoir on Salt Fork of Wills Creek in Guernsey County.

The July 1965 flood control plan will reduce natural average annual flood damages in downstream areas from $10.5 million to about $2.7 million and in upstream areas from $3.1 million to about $3.0 million. (Table MU-1). While a high degree of flood control prevails in most areas below the existing projects, there remain unprotected tributary areas where recurrent damages may be expected from extreme overflows. Notable among these are the Upper Wills Creeks, and the Upper Tuscarawas River. Mansfield and Zanesville are major damage centers, with a problem area of a lesser degree located at Crooksville.

The northeastern portion of Mansfield along both sides of Rocky Fork from above Longview Avenue to below Park Avenue is primarily an industrial center and is subject to the most serious flooding. Streamflow during high stages is restricted by several bridges and insufficient channel capacities. A study of the problem at Mansfield is underway.

The City of Zanesville is located at the confluence of the Licking and Muskingum Rivers with urban developments located along both banks of these two rivers. Inadequate channel capacities, aggravated by encroachments on the channel area result in flood damages. However, the existing 15 reservoirs have alleviated the problem to a considerable degree, and the city is subject to damage from only major floods. A local protection project at Zanesville has been authorized, but the project lacks economic feasibility at this time.

Crooksville is located on Moxahala Creek, a tributary of Jonathan Creek, in the southwestern portion of the basin. Due to irregularity of the channel and naturally inadequate channel capacity, the town is subject to periodic flooding. In an investigation of the Moxahala-Jonathan Creek sub-basin, preliminary studies concluded that partial protection for Crooksville may be justified.

Downstream residual average annual damages of $2.7 million are projected to increase to $11.6 million by 2020. (Table MU-3). The potential future flood control plan for the downstream areas of the basin consists of ten reservoirs and one major and two small local protection projects. (Table MU-4 and Figure MU-1).

Annual damages of $3 million in upstream areas are expected to increase to $7.5 million by 2020 without further project development.

There are 24 potential feasible upstream watershed projects, with 850 miles of channel improvement and 250 retarding structures, which could provide storages of 156,600 acre-feet for floodwater detention and 29,400 acre-feet for sediment. (Table MU-4 and Figure MU-1). The structures would control 1,123 square miles of drainage area or about 28 percent of the total area within potential watersheds. The average annual flood damages occurring within these watersheds are estimated at $2.3 million, attributable as follows: 61 percent to agriculture; 7, transportation facilities, and 32, urban developments. The damage per square mile of their watershed area is estimated at $584. The potentially feasible projects would reduce average annual damages in upstream areas by $1.9 million. These projects would protect 118,590 acres of flood plain and present an opportunity for enhancing land values through an estimated annual increase in productivity of $1.1 million. Of the basin's drainage area, potential feasible watershed projects would cover 50 percent, and their impoundments control about 14. Because of this, they have a good potential for peak discharge and sediment reductions in the downstream areas.

A basin-wide study is underway to determine if the existing plan for flood control assures orderly and sound development and coordination of water resources. It will examine the existing reservoirs to determine if additional improvements or reallocation of storage are needed to obtain optimum efficiency. The basin-wide study will satisfy all outstanding resolutions for survey studies of sub-basins of the Muskingum River Basin.

As of September 1967, a flood plain information study has been completed along Nimishillen Creek from its mouth to the Canton area. A similar one is underway along the Tuscarawas River, in Stark County, and one is authorized for the Tuscarawas River from Akron to the Stark County Line.

Table MU-1

FLOOD PLAIN DATA - MUSKINGUM RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

	Average Annual Damages ($1,000)		100 Year Modified Flood(1)		Composite Historical Flood(2)	
Category	Natural	Modified(1)	Area Inundated (Acres)	Damages ($1,000)	Area Inundated (Acres)	Damages ($1,000)
Agricultural Crop	2,037	1,001		Minor		100,000
Agricultural Non-Crop	1,061	501		Minor		19,295
Residential	2,289	426		2,185		58,000
Commercial	1,659	226		2,563		99,185
Industrial	1,869	146		3,168		125,970
Other(3)	1,586	448		1,884		97,475
TOTAL	10,501	2,748	20,000	9,800	38,000	499,925

B. UPSTREAM AREAS

	Average Annual Damages ($1,000)	
Category	Natural	Modified(1)
Crop and Pasture	1,469	1,411
Other Agriculture	251	248
Transportation Facilities	256	230
Urban	800	800
Sediment and Erosion	29	29
Indirect(4)	284	273
TOTAL	3,089	2,991

	100 Year Modified Flood(1)	
Category	Area Inundated (Acres)	Damages ($1,000)
Crop		17,072
Non-Crop		4,213
Residential		5,500
Commercial and Industrial		4,081
Other(3)		3,135
TOTAL	178,070	34,001

NOTES: (1) Modified by projects in the July 1965 Flood Control Plan.
(2) Floods used for composite: March 1913, January-February 1937.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruption to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

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Table MU-2

JULY 1965 FLOOD CONTROL PLAN

MUSKINGUM RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Atwood	C	F,R	70	49.7	23.6	6.3	26.1	7.0	26.1
Beach City	C	F,R	300	71.7	1.7	0.1	70.0	4.4	70.0
Bolivar	C	F	502	149.6			149.6	5.6	149.6
Charles Mill	C	F,R	216	88.0	7.4	0.6	80.6	7.0	80.6
Clendening	C	F,R	70	54.0	26.5	7.1	27.5	7.4	27.5
Dillon	C	F,R	748	274.0	13.1	0.3	260.9w[3]	6.6	256.6s[3]
Dover	C	F,R	777[5]	203.0	1.0	-	202.0	4.9	202.0
Leesville	C	F,R	48	37.4	19.5	7.6	17.9	7.0	17.9
Mohawk	C	F	817[6]	285.0	-	-	285.0	6.5	285.0
Mohicanville	C	F	269	102.0	-	-	102.0	7.1	102.0
Peidmont	C	F,R	84	66.7	34.5	7.7	32.2	7.2	32.2
Pleasant Hill	C	F,R	199	87.7	13.5	1.3	74.2	7.0	74.2
Senecaville	C	F,R	121	88.5	43.5	6.7	45.0	7.0	45.0
Tappan	C	F,R	71	61.6	35.1	9.3	26.5	7.0	26.5
Wills Cr	C	F,R	723[7]	196.0	6.0	0.2	190.0	4.9	190.0
N Br Kokosing	AP	F,R	45	14.9	0.7	0.3	14.2	6.0	14.2

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin Watershed Project	Purpose[4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Chippewa, Ohio	FP,R	188.0	9	39.0	406	6,294	2,767	9,467	33.2

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Newark, Ohio, Licking	C	1.0	-	6.0	
Roseville, Ohio, Moxahala Creek	C	1.0	-	1.4	
Massillon, Ohio, Tuscarawas River	C	3.0	Minor	3.2	Press Conduit 0.8
Mt. Vernon, Ohio, Kokosing River	UC	-	-	-	Clear & Snagging 4.0

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status
Snagging & Clearing Projects	
Black Fork Creek below Charles Mill Dam, Ohio	C
Canton, Ohio, Nimishillen Creek	C

II. NON-FEDERAL

A. RESERVOIRS

Reservoir	Status[8]	Purpose[2]	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1,000 Ac Ft)	Total Storage (1,000 Ac Ft)
Salt Fork	UC	F,M,R	160	92.4	130.0

NOTES: (1) July 1965 Status: C - Completed AP - Authorized - advanced planning UC - Under construction

(2) Purpose: F - Flood Control M - Water Supply R - Recreation

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention R - Recreation

(5) Net drainage area below Atwood, Bolivar, and Leesville Dams.

(6) Net drainage area below Charles Mill, Pleasant Hill, and Mohicanville Dams

(7) Net drainage area below Senacaville Dam

(8) Status of non-Federal projects as shown in Appendix J, "State Laws, Policies and Programs," Ohio River Basin Comprehensive Survey
UC - Under construction

Table MU-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

MUSKINGUM RIVER BASIN

	Average Annual Damages ($1,000)			
	Residual	Projected		
Area Location	1965	1980	2000	2020
Downstream	2,748	3,621	6,682	11,641
Upstream	2,991	3,768	5,565	7,511
Total Basin	5,739	7,389	12,247	19,152

Table MU-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

MUSKINGUM RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Drainage Area Controlled (sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Frazeysburg	D	62	52.0	62.0
Utica	P	114	28.0	82.0
Conser Run	P	15	4.2	5.1
Middlebranch	P	27	7.2	9.3
Hugle Run	P	9	3.3	8.2
Boggs Fork	P	15	4.0	5.0
Skull Fork	P	46	12.5	15.0
Ogg	P	12	3.3	8.5
Millersburg	I	381	77.0	77.0
Valley Run	P	25	7.9	15.1

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
24	4,003	250	1,123	1,250,520	40,490	850

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Zanesville, Ohio, Licking & Muskingum Rivers (2)	I			

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Remarks
Mansfield, Ohio, Rocky Fork	P	Channel improvement
Crooksville, Ohio, Moxahala Creek	P	Channel improvement

NOTES:

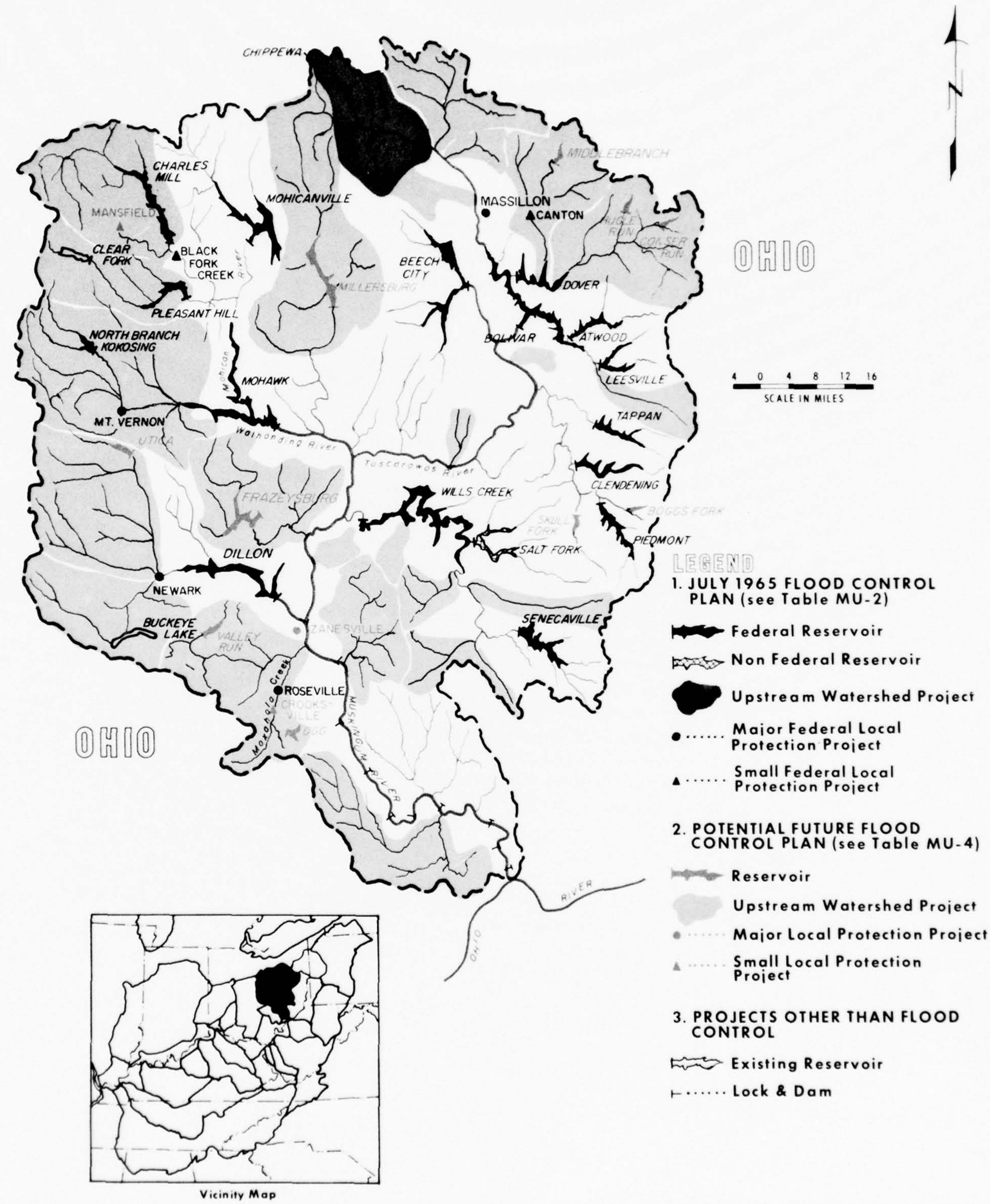
(1) July 1965 Status

D - Authorized project - Deferred status

I - Authorized project - Inactive status

P - Potential project

(2) Project dimensions not defined at this time



OHIO RIVER BASIN COMPREHENSIVE SURVEY

MUSKINGUM RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE MU-1

5. Little Kanawha River Basin

The Little Kanawha River, from its source on the western slopes of the Allegheny Mountains to its mouth, drains an area of about 2,320 square miles and lies wholly within the State of West Virginia. With the exception of Parkersburg at the mouth of the stream, there are no large towns in the basin. The topography of the basin is hilly to mountainous, with generally steep slopes and narrow valleys. Average annual precipitation over the basin amounts to about 44 inches, with annual runoff amounting to about 19 inches.

The July 1965 Federal flood control plan consists of one small channel improvement and two upstream watershed projects. (Table LK-2 and Figure LK-1). The basin's two watershed projects are the completed Bond Creek in Ritchie County, and Saltlick Creek in Braxton County, about 55 percent complete. These encompass an area of 64 square miles and the structures will control 20 square miles of drainage area. In them, six retarding structures have storages of 316 acre-feet for sediment, 4,040 for floodwater detention, and 147 for other uses. The flood prevention cost of the six is $1 million and they will prevent about $48,000 in annual upstream damages on 1,168 acres of flood plain, reducing average annual damages in upstream areas from $828,000 to about $780,000. (Table LK-1).

There are no major urban damage centers in the basin; however, flood damages do occur at Burnsville, Glenville, and Grantsville, on the Little Kanawha River. Four reservoirs are included in the potential future plan for downstream areas. (Table LK-4 and Figure LK-1). Downstream damages of $137,000 annually have been projected to increase to $568,000 by 2020. (Table LK-3). Two of the four reservoirs in the potential future plan are the Burnsville and West Fork Reservoirs authorized by the 1938 Flood Control Act, but construction was deferred because of marginal justification. A recent study found the Burnsville project economically feasible. This reservoir will reduce the basin's residual damages in downstream areas to about $28,000 annually and minimize flood problems at Burnsville, Glenville, and Grantsville. In addition, it will provide flood reductions on the Ohio River at Parkersburg and downstream. Continued investigations are considering leading Creek Reservoir as an alternate to the authorized Steer Creek Reservoir.

Average annual damages of about $780,000 in upstream areas are expected to increase to about $2 million by 2020 without further projects. (Table LK-3). Structural measures supplementing land treatment have been found potentially feasible in two additional upstream watersheds. They consist of 35 retarding structures with storages of 7,400 acre-feet for floodwater detention and 1,100 acre-feet for sediment. (Table LK-4 and Figure LK-1). These potential projects comprise an area of 74 square miles and their impoundments would control 41 of these. The average annual flood damages occurring within these watersheds are estimated at $186,000 with more than 65 percent of the damages attributed to urban developments. The damage per square mile of their watershed area is estimated at $2,513. The potentially feasible projects would reduce

average annual damages in upstream areas by $149,000. They would protect about 980 acres of flood plain mostly in urban and other built-up areas, and the improvements could enhance agricultural and urban land values.

As of September 1967, flood plain information studies are underway at Glenville and Grantsville, located on the Little Kanawha River.

Table LK-1

FLOOD PLAIN DATA - LITTLE KANAWHA RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Historical Flood(2) Area Inundated (Acres)	Historical Flood(2) Damages ($1,000)
Agricultural Crop	26	26		225		
Agricultural Non-Crop	14	14		300		
Residential	30	30		2,000		
Commercial	22	22		475		
Industrial	24	24		Minor		
Other(3)	21	21		710		
TOTAL	137	137	13,000	3,710	(4)	1,824

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(5)
Crop and Pasture	48	41
Other Agriculture	69	63
Transportation Facilities	129	105
Urban	508	506
Sediment and Erosion	5	2
Indirect(6)	69	63
TOTAL	828	780

Category	100 Year Modified Flood(5) Area Inundated (Acres)	100 Year Modified Flood(5) Damages ($1,000)
Crop		225
Non-Crop		345
Residential		2,130
Commercial and Industrial		610
Other(3)		590
TOTAL	20,890	3,900

NOTES:
(1) Minor Modification.
(2) March 1967 Flood. Breakout of damages by category not available.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Data not available.
(5) Modified by Soil Conservation Service flood control projects constructed, under construction, and those approved for operations as of July 1965.
(6) Indirect damages including interruptions to travel due to road damage, interruption pf public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table LK-2

JULY 1965 FLOOD CONTROL PLAN

LITTLE KANAWHA RIVER BASIN

I. FEDERAL

A. RESERVOIRS

NONE

B. UPSTREAM WATERSHED PROJECTS

Subbasin and Watershed Project	Purpose (2)	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Bond's Creek, W Va	FP,F&WL	14.7	1	0.5	11	86	147	344	5.8
Saltlick Creek, W Va	FP	49.5	5	19.7	305	3,954	-	4,259	-

C. MAJOR LOCAL PROTECTION PROJECTS

NONE

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status
Snagging & Clearing Project	
Cairo, W Va, North Fork Hughes River	C

II. NON-FEDERAL

NONE

NOTES: (1) July 1965 Status: C - Completed

(2) Purpose: FP - Flood prevention F&WL - Fish and wildlife development

Table LK-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

LITTLE KANAWHA BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	137	143	312	568
Upstream	780	1,039	1,421	1,956
Total Basin	917	1,182	1,733	2,524

Table LK-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

LITTLE KANAWHA RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
N. Fork Hughes River	P	90	25.0	30.0
West Fork	D	238	77.1	85.1
Burnsville	A	166	58.0	66.0
Leading Creek	P	146	55.6	62.4

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
2	74	35	41	20,954	1,018	0

C. MAJOR LOCAL PROTECTION PROJECTS

None defined at present.

D. SMALL LOCAL PROTECTION PROJECTS

None defined at present.

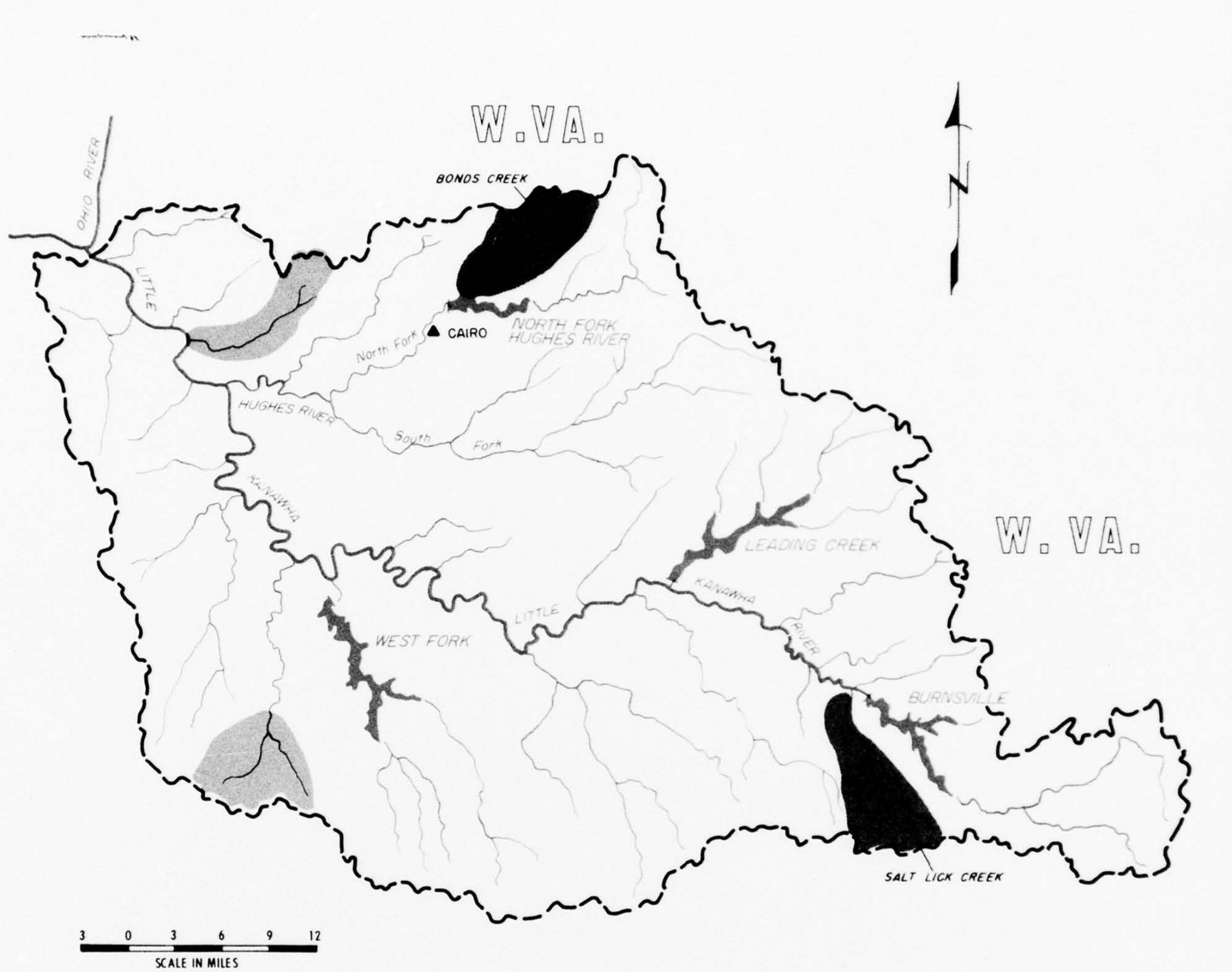
NOTES:

(1) July 1965 Status

A - Authorized project - Active status

D - Authorized project - Deferred status

P - Potential project



W. VA.

LEGEND

1. JULY 1965 FLOOD CONTROL PLAN (see Table LK-2)

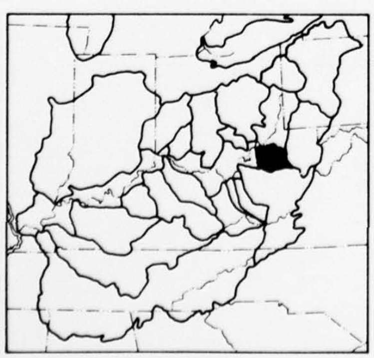
Upstream Watershed Project

Small Federal Local Protection Project

2. POTENTIAL FUTURE FLOOD CONTROL PLAN (see Table LK-4)

Reservoir

Upstream Watershed Project



VICINITY MAP

OHIO RIVER BASIN COMPREHENSIVE SURVEY

LITTLE KANAWHA RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE LK-1

6. Hocking River Basin

The Hocking River, a southeastward flowing tributary of the Ohio River, enters the Ohio at Hockingport, Ohio, 782 miles above the mouth. The total drainage area of the Hocking River Basin which lies entirely within the State of Ohio is about 1,190 square miles. Most of the larger communities in the basin such as Lancaster, Logan, Nelsonville, and Athens are located along the main stem Hocking River. Normal annual precipitation over the basin averages about 37 inches. Average annual snowfall is about 18 inches (unmelted) and represents only a minor portion of the total annual precipitation.

The March 1907 flood is the maximum of record for most of the Hocking River Basin. Its recurrence, without the present control works, would cause downstream damages of about $3.8 million. This is about one and a half times as great as those expected to occur from the modified 100-year flood. (Table HO-1).

The July 1965 Federal flood control plan in the basin consists of one reservoir and two upstream watershed projects. Non-Federal interests have completed numerous levees along the Hocking River and Rush Creek and the City of Lancaster has completed a channel improvement project on the Hocking River which bisects the town. (Table HO-2 and Figure HO-1).

The basin's two authorized watershed projects, Upper Hocking which has been completed and Rush Creek, are located in Fairfield, Hocking and Perry Counties. These cover an area of 286 square miles, with approximately 43 percent controlled behind structures. The flood prevention cost of the pair is $5.2 million and they are expected to prevent $144,000 in annual upstream damages on 14,063 acres of flood plain.

The July 1965 flood control plan will reduce natural average annual flood damages in downstream areas from $398,000 to $391,000 and in upstream areas from $526,000 to $382,000. (Table HO-1). Flooding along the main stem of the Hocking River results in serious and frequent damages at Athens. Its existing annual damages of $232,000 comprise almost 60 percent of the basin's downstream total. Logan, Nelsonville and other communities located along the Hocking River have problems of a lesser degree. These, along with the rural reaches, suffer nearly all the remaining damages.

The recent March 1964 flood on the Hocking River inundated approximately 1,300 acres within and immediately adjacent to the city of Athens. About 28 percent of this area has been extensively developed by residences, and commercial, industrial and institutional establishments. The expansion of facilities to accommodate the rapidly increasing enrollment of Ohio University has been seriously hampered in the past few years. The unavailability of land not susceptible to flooding has forced the University to develop well into the flood plain. Their most recently constructed facilities are subject to flooding on the average of about once in every 15 years. The majority of land available for future construction is subject to flooding more frequently than once in 10 years.

Downstream damages of $391,000 are projected to increase five times by 2020. (Table HO-3). To reduce these projected downstream damages, five reservoirs, and one major and one small local protection projects are included in the potential future plan for downstream areas. (Table HO-4 and Figure HO-1). The major local protection project in the future plan is the recently authorized Athens channel improvement considered as a potential project in this appendix. This improvement supplemented by the completed Tom Jenkin's Reservoir and the authorized Logan Reservoir, also included in the potential program, would substantially reduce flooding at Athens. A restudy of the authorized Logan Reservoir project is underway. At Logan and Nelsonville, local protection projects warrant further consideration to solve flood problems at these localities.

Upstream residual damages of $382,000 are expected to increase to $1.2 million without further project development. (Table HO-3). Structural measures supplementing land treatment have been found potentially feasible in four additional upstream watersheds. (Table HO-4 and Figure HO-1). They consist of 95 miles of channel improvement and 27 retarding structures, providing storages of 10,060 acre-feet for floodwater detention and 2,350 for sediment. They would control 88 square miles or approximately 28 percent of the total area in potential watersheds. The average annual flood damages occurring within them are estimated at $126,000, attributed as follows: 77 percent, agriculture; 6, transportation facilities; and 17, urban developments. The damage per square mile of their watershed area is estimated at $403. The potential feasible projects would reduce average annual damages in upstream areas by $101,000. They would protect about 8,747 acres of flood plain and provide enhanced land values through an increase in annual productivity estimated at $25,000.

Flood plain information studies are underway as of September 1967 at Logan, Athens and Nelsonville.

Table HO-1

FLOOD PLAIN DATA - HOCKING RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Historical Flood(2) Area Inundated (Acres)	Historical Flood(2) Damages ($1,000)
Agricultural Crop	95	93		110		165
Agricultural Non-Crop	Minor	Minor		Minor		Minor
Residential	180	177		1,433		2,208
Commercial	37	36		260		434
Industrial	13	12		118		181
Other(3)	73	73		500		788
TOTAL	398	391	12,000	2,421	18,000	3,776

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(4)
Crop and Pasture	305	223
Other Agriculture	37	32
Transportation Facilities	36	28
Urban	92	61
Sediment and Erosion	6	4
Indirect(5)	50	34
TOTAL	526	382

Category	100 Year Modified Flood(4) Area Inundated (Acres)	100 Year Modified Flood(4) Damages ($1,000)
Crop		1,092
Non-Crop		172
Residential		404
Commercial and Industrial		296
Other(3)		112
TOTAL	41,510	2,076

NOTES:
(1) Modified by projects in the July 1965 Flood Control Plan.
(2) March 1907 flood.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Modified by Soil Conservation Service flood control projects constructed, under construction, and those approved for operations as of July 1965.
(5) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table HO-2

JULY 1965 FLOOD CONTROL PLAN

HOCKING RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Tom Jenkins	C	F,M,R	33	26.9	3.5	2.0	17.6	10.1	17.6

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose[3]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Rush Creek, Ohio	FP,M&I,R	236.7	23	96.4	6,238	9,716	2,252	18,206	22.1
Upper Hocking, Ohio	FP	49.1	8	24.4	355	8,710		9,065	5.5

C. MAJOR LOCAL PROTECTION PROJECTS

None

D. SMALL LOCAL PROTECTION PROJECTS

None

II. NON-FEDERAL

A. RESERVOIRS

None

B. LOCAL PROTECTION PROJECTS

Project Location	Status[4]	Remarks
Hocking River & Rush Creek Levees	C	Completed by local interests[5]
Lancaster Channel Improvement, Hocking River	C	Completed by the City of Lancaster, Ohio

NOTES: (1) July 1965 Status: C - Completed

(2) Purpose: F - Flood control M - Water supply R - Recreation

(3) Purpose: FP - Flood prevention M&I - Municipal and industrial water supply R - Recreation

(4) Status of non-Federal projects as shown in Appendix J, "State Laws, Policies and Programs," Ohio River Basin Comprehensive Survey
C - Completed

(5) Not shown on Figure HO-1

Table HO-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

HOCKING RIVER BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	391	585	1,125	2,161
Upstream	382	428	772	1,211
Total Basin	793	1,013	1,897	3,372

Table HO-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

HOCKING RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Logan	D	84	35.9	78.0
Monday Creek	P	77	30.6	49.3
Federal Creek	P	139	56.7	74.4
Sugar Grove	P	231	42.4	50.4
McLeish	P	31	9.6	14.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
4	313	27	88	69,076	2,215	95

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles		
		Earth Levee	Concrete Flood Wall	Channel
Athens, Ohio, Hocking River	P	-	-	4.2

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Remarks
Rockbridge, Ohio, Hocking River	P	(2)

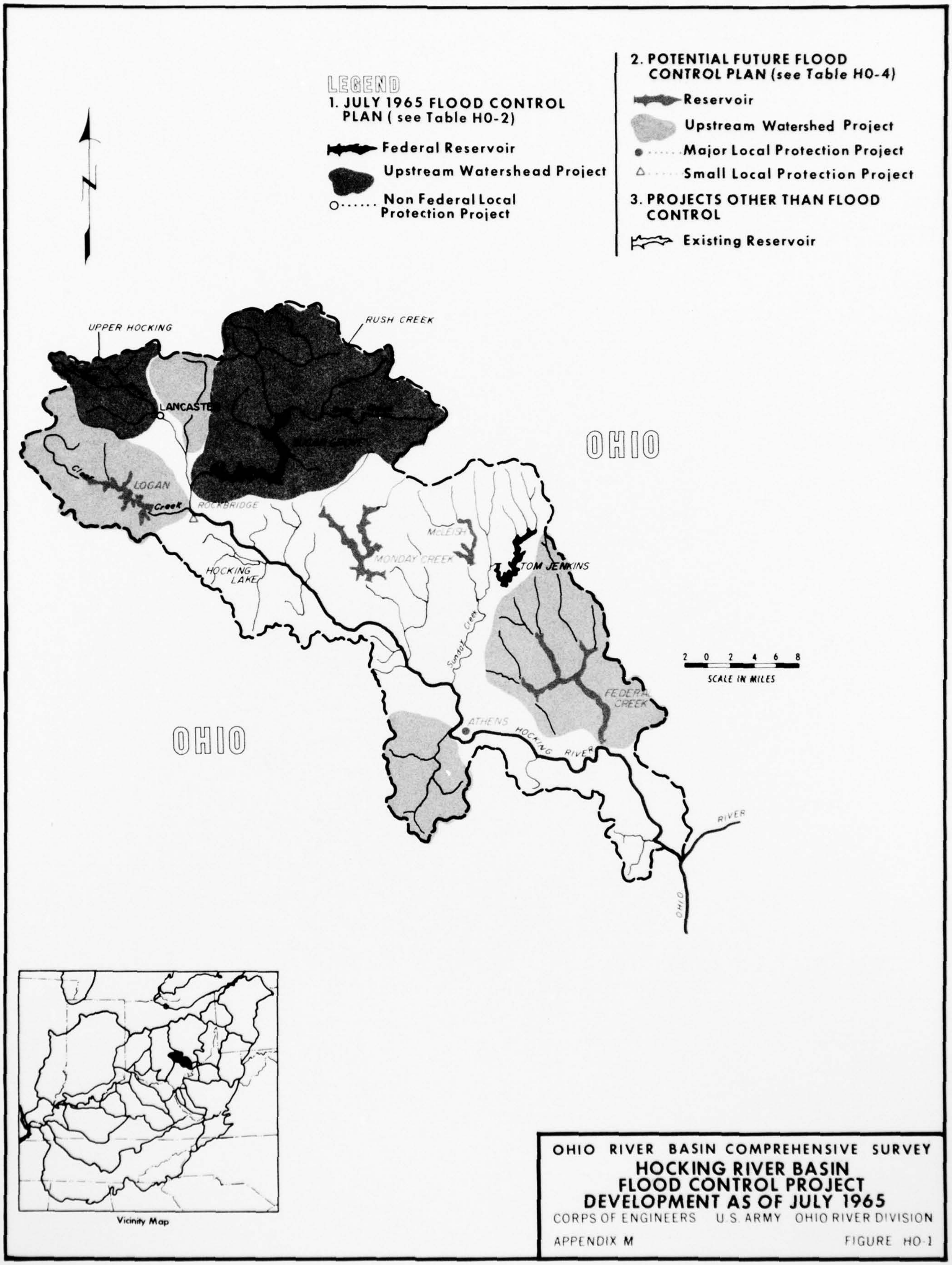
NOTES:

(1) July 1965 Status

D - Authorized project - Deferred status

P - Potential project

(2) Project dimensions not defined at this time.



OHIO RIVER BASIN COMPREHENSIVE SURVEY
HOCKING RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965
CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION
APPENDIX M FIGURE HO-1

7. Kanawha River Basin

The Kanawha River is formed by the junction of the New and Gauley Rivers in southern West Virginia, flows 97 miles in a general northwesterly direction and enters the Ohio at Point Pleasant, West Virginia, 715 miles above the mouth. The basin which is situated in North Carolina, Virginia and West Virginia is generally characterized by mountainous terrain with streams flowing through steep, narrow valleys, and is rather sparsely developed, except for the flood plains of the main stem and major tributaries. About 30 percent of the total basin population resides in the heavily industrialized area along the Kanawha River.

Major floods along the Kanawha River and its larger tributaries are infrequent. Yet, there have been some widespread winter storms, often augmented by snow melt and by hurricane-type storms. The maximum flood of record at Charleston, located on the Kanawha River, occurred in September 1861. However, the lower reach of the Kanawha had its greatest flood in 1897. More recent floods of 1945, 1963 and others established the record in the upper tributaries. The minor tributaries are prone to flash floods resulting from intense summer thunderstorms and rapid runoff.

The July 1965 Federal flood control plan in the basin consists of three reservoirs, five upstream watershed projects, and three major and four small local protection projects. (Table KA-2 and Figure KA-1). The flood control plan will reduce natural average annual flood damages in downstream areas from $14.5 million to about $4 million, and in upstream areas from $3.2 million to about $3.0 million. (Table KA-1).

The three reservoirs included in the plan control 5,905 square miles of the drainage area and contain over 1.2 million acre-feet of flood control storage. The five authorized watershed projects will cover 87 square miles of drainage area and contain 23 miles of channel improvement and 19 retarding structures. Those completed are in Pulaski County, Virginia, Pocahontas and Mercer Counties, West Virginia, and one is under construction in Mercer County which will control runoff from 21 square miles and provide storages of 4,188 acre-feet for floodwater detention and 385 for sediment. The flood prevention cost is about $2.1 million and they will prevent $155,000 annual damages on 2,437 acres of flood plain.

Since the largest inundation occurred prior to the intensive development of the Kanawha Valley, a false sense of security exists in the flood plain. Although the existing reservoir system affords an ultimately significant degree of protection, damages will still occur annually and would be extensive during a major flood. Charleston and St. Albans-Nitro, West Virginia are the principal flood damage centers on the Kanawha River with annual damages estimated at $334,000 and $100,000, respectively. Because of their proximity to the mouth of the Kanawha, these two communities are subject not only to headwater flooding, but to Ohio River backwater flooding as well. Since the topography of the area limits the use of local protection projects to solve flood problems at these two locations,

the most feasible means of providing protection from headwater flooding for these localities would be the construction of reservoirs above the area. Future flood control storage development in the Ohio River Basin above the mouth of the Kanawha would reduce Ohio River backwater flooding.

Photo 17. Charleston, West Virginia. The flood of September 1861 under natural conditions would have inundated all of the area between Kanawha Boulevard adjacent to the river on the far bank and the foot of the hills shown in the background.

In addition to flooding along the Kanawha River, disastrous floods in terms of lives and property have occurred in narrow tributary valleys such as Armstrong, Paint and Cabin Creeks, and on several small tributaries of the Kanawha and Elk Rivers in the vicinity of Charleston.

Areas in the Coal River sub-basin susceptible to damages during major floods are Whitesville, Sylvester, Seth, Madison, and Danville, West Virginia. Potential reservoir projects are being reviewed in the current comprehensive study of the Kanawha River Basin.

In the Gauley River sub-basin, there are flood problems along Cherry River and tributaries in the vicinity of Richwood and along the upper reaches of Meadow River and tributaries near East Rainelle, West Virginia. The Summersville Reservoir will protect the Gauley River but not affect the other two areas.

In the Elk River sub-basin, there are still residual damages downstream from Sutton Reservoir, particularly in the Clendenin, West Virginia area. The potential Birch Reservoir project would reduce these residual damages.

While only moderately developed, the Greenbrier Valley experiences widespread flood damage to permanent and summer residences, commercial establishments and transportation facilities. Greenbrier Valley communities, such as Alderson, Ronceverte and Marlinton suffer from frequent inundation of low lying improvements.

Infrequent floods along the Upper New River cause some damages in Austinville, Allisonia, Radford, and Belspring, Virginia. Potential multi-purpose reservoir projects in the Upper New River Area could provide feasible protection to these localities.

The basin's flood problem is currently being investigated in more detail in connection with the Kanawha Basin Comprehensive Survey of water and related land resources. Field investigations are scheduled for completion in Fiscal Year 1969.

Average annual downstream damages of $4 million are expected to increase about four times by the year 2020, assuming further control and prevention measures are not implemented. (Table KA-3). Included in a potential future flood control plan for downstream areas are 20 reservoirs. (Table KA-4 and Figure KA-1).

Upstream average annual damages of $3 million are expected to increase to about $7.6 million by 2020 without additional development. (Table KA-3). There are 32 potentially feasible watershed projects which would protect 2,312 square miles of drainage area. (Table KA-4 and Figure KA-1). The 35 miles of channel improvements and 155 retarding structures could provide storages of 221,756 acre-feet for floodwater detention and 26,000 for sediment, with the impoundments controlling about 975 square miles of drainage area. The average annual flood damages within these potential project watersheds are estimated at $1.6 million, with more than 77 percent attributed to urban developments. The damage per square mile of their watershed area is estimated at $700. The projects would reduce average annual flood damages in upstream areas by $1.3 million and would protect about 19,072 acres of flood plain. The improvements could enhance land values through an estimated annual $16,000 increase in productivity.

A flood plain information study is underway as of September 1967 along the Little Coal River at Madison, West Virginia.

Table KA-1

FLOOD PLAIN DATA - KANAWHA RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Average Annual Damages ($1,000)			100 Year Modified Flood(1)		Composite Historical Flood(2)	
Category	Natural	Modified(1)	Area Inundated (Acres)	Damages ($1,000)	Area Inundated (Acres)	Damages ($1,000)
Agricultural Crop	2,813	1,456		12,197		Minor
Agricultural Non-Crop	1,465	728		6,104		Minor
Residential	3,161	620		5,198		102,358
Commercial	2,291	328		2,752		49,037
Industrial	2,580	212		1,781		36,000
Other(3)	2,190	652		5,464		27,448
TOTAL	14,500	3,996	25,260	33,496	30,000	214,843

B. UPSTREAM AREAS

Average Annual Damages ($1,000)		
Category	Natural	Modified(1)
Crop and Pasture	120	114
Other Agriculture	134	131
Transportation Facilities	676	659
Urban	1,841	1,735
Sediment and Erosion	1	0
Indirect(4)	420	398
TOTAL	3,192	3,037

100 Year Modified Flood(1)		
Category	Area Inundated (Acres)	Damages ($1,000)
Crop		625
Non-Crop		720
Residential		5,800
Commercial and Industrial		4,415
Other(3)		3,625
TOTAL	75,230	15,185

NOTES: (1) Modified projects in the July 1965 Flood Control Plan.
(2) Floods used for composite: September 1861 and 1878, February 1897.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table KA-2

JULY 1965 FLOOD CONTROL PLAN

KANAWHA RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Purpose (2)	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage		Flood Control Storage		
							Major Flood Season		Conservation Season
					1,000 Ac Ft	Inches	1,000 Ac Ft	Inches	1,000 Ac Ft
Bluestone	C	F	4,565	631.0	30.9	0.1	600.1w (3)	2.5	594.5s (3)
Sutton	C	F,Q	537	265.3	4.1	0.1	261.2w	9.1	201.1s
Summersville	UC	F,Q	803	413.8	23.0	0.5	390.8w	9.1	227.4s

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose (4)	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage				Channel Improvements (Miles)
					Sediment (Ac Ft)	Floodwater (Ac Ft)	Other Uses (Ac Ft)	Total (Ac Ft)	
Brush Creek, W Va	FP,M&I	34.8	14	16.6	280	3,238	153	3,671	5.9
Dave's Fork-Christian's Fork, W Va	FP	6.5	3	2.4	43	502		545	1.2
Marlin Run, W Va	FP	1.6	1	1.2	15	272		287	
Back Creek, Va	FP	34.9							11.1
Big Ditch Run, W Va	FP,R	9.0	1	1.2	47	176	372	595	5.0

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles		
		Earth Levee	Concrete Flood Wall	Channel
E. Rainelle, W Va, Meadow River, Sewell & Biggs Creeks	C	-	-	4.4
Galax, Va, Chestnut Creek	C	-	-	2.6
Princeton, W Va, Brush Creek	C	-	-	3.9

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status
Snagging & Clearing Projects	
Richwood, W Va, Cherry River	C
Bramwell, W Va, Bluestone River	C
Montcalm, W Va, Bluestone River	UC
Pax, W Va, Paint Creek	UC

II. NON-FEDERAL

None

NOTES:
(1) July 1965 Status: C - Completed UC - Under construction

(2) Purpose: F - Flood R - Recreation Q - Water Quality

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention R - Recreation M&I - Municipal and industrial water supply

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OHIO RIVER BASIN COMPREHENSIVE SURVEY. VOLUME XIV. APPENDIX M. --ETC(U)
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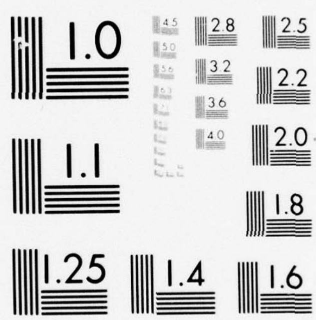

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Table KA-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

KANAWHA RIVER BASIN

Area Location	Average Annual Damages ($1,000)			
	Residual	Projected		
	1965	1980	2000	2020
Downstream	3,996	4,431	9,631	17,440
Upstream	3,037	4,104	5,558	7,556
Total Basin	7,033	8,535	15,189	24,996

Table KA-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

KANAWHA RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Little River (Upper)	P	198	31.7	149.4
Reed Creek	P	258	41.3	114.5
Big Reed Island	P	259	41.4	391.1
Walker Creek	P	303	48.0	310.0
S Fork New River	P	200	32.0	175.0
Big Sandy Creek	P	94	20.0	53.3
Marsh Fork	P	44	10.0	20.0
Birch	D	142	46.2	105.4
Moores Ferry	D	1,130	361.0	421.0
Buffalo Creek	P	114	24.3	66.9
New River	P	630	100.0	580.0
Little River (Lower)[2]	P	339[3]	23.0	107.0
Kimberling Creek	P	90	15.0	120.0
Bluestone River	P	232	40.0	32.0
Indian Creek	P	151	23.0	87.0
Clear Fork	P	39	18.8	20.9
Meadow River	P	322	40.0	140.0
Poca	I	245	186.0	194.0
Big Bend	I	1,631	107.5	108.5
Greenbrier	P	350	96.0	561.0
Anthony Lake	P	143	38.0	301.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
32	2,312	155	975	502,728	10,998	35

C. MAJOR LOCAL PROTECTION PROJECTS

None defined at present.

D. SMALL LOCAL PROTECTION PROJECTS

None defined at present.

NOTES:

(1) July 1965 Status:

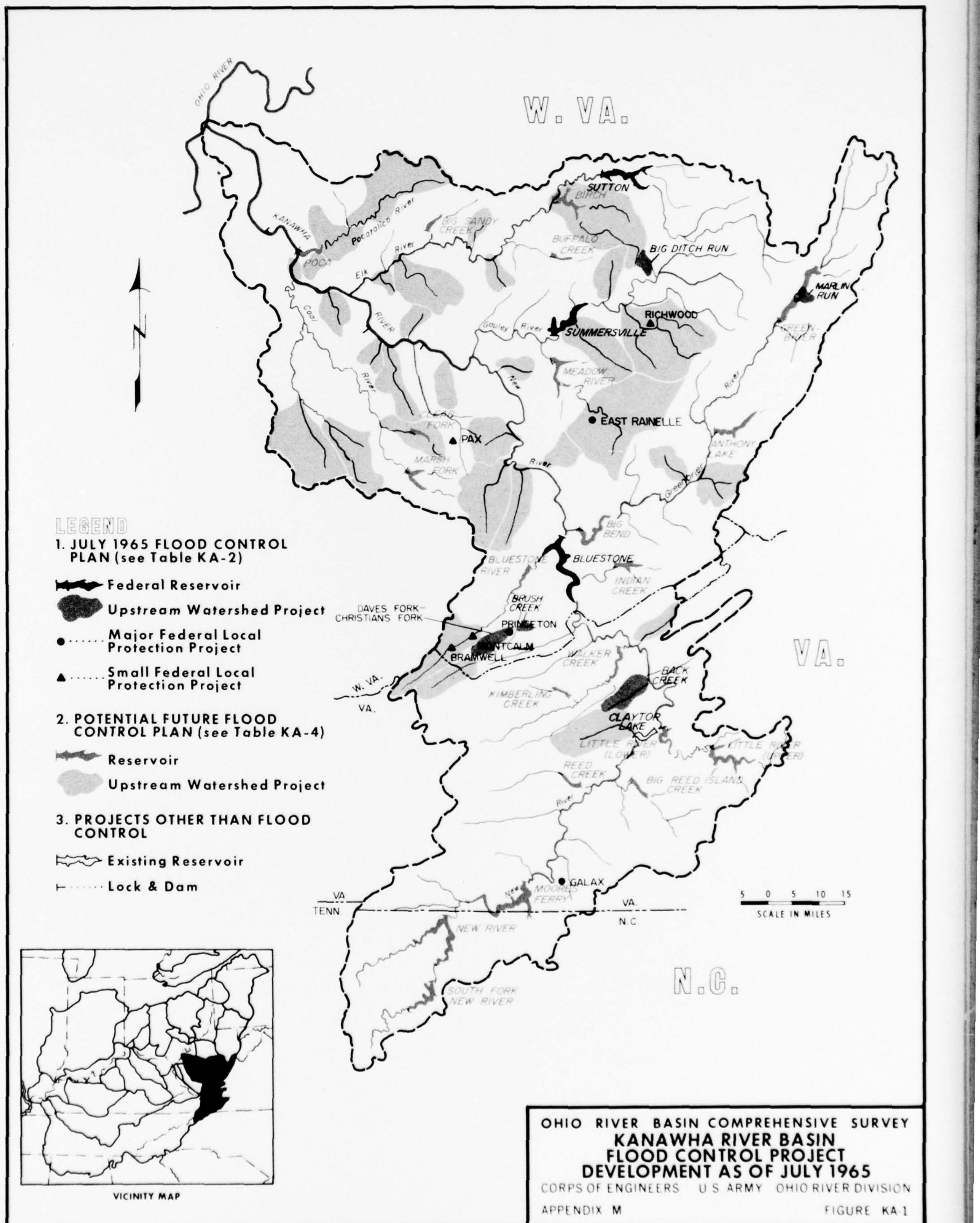
D - Authorized project - Deferred status

I - Authorized project - Inactive status

P - Potential project

(2) Alternate to upper site

(3) Uncontrolled area below upper site


W. VA.
VA.
N.C.
OHIO RIVER
KANAWHA
POCA
Pocatalico River
BIG SANDY CREEK
Elk River
Coal River
SUTTON
BIRCH
BUFFALO CREEK
BIG DITCH RUN
MARLIN RUN
RICHWOOD
Gauley River
SUMMERSVILLE
GREENBRIER
MEADOW RIVER
New
EAST RAINELLE
CLEAR FORK
PAX
MARSH FORK
River
ANTHONY LAKE
Greenbrier
BIG BEND
BLUESTONE
BLUESTONE RIVER
INDIAN CREEK
BRUSH CREEK
DAVES FORK-CHRISTIANS FORK
PRINCETON
MONTCALM
BRAMWELL
WALKER CREEK
BACK CREEK
W. VA.
VA.
KIMBERLING CREEK
CLAYTOR LAKE
LITTLE RIVER (LOWER)
LITTLE RIVER (UPPER)
REED CREEK
BIG REED ISLAND CREEK
River
GALAX
New
MOORES FERRY
VA
TENN.
VA.
N.C.
NEW RIVER
SOUTH FORK NEW RIVER
5 0 5 10 15
SCALE IN MILES
LEGEND
1. JULY 1965 FLOOD CONTROL PLAN (see Table KA-2)
Federal Reservoir
Upstream Watershed Project
Major Federal Local Protection Project
Small Federal Local Protection Project
2. POTENTIAL FUTURE FLOOD CONTROL PLAN (see Table KA-4)
Reservoir
Upstream Watershed Project
3. PROJECTS OTHER THAN FLOOD CONTROL
Existing Reservoir
Lock & Dam
VICINITY MAP
OHIO RIVER BASIN COMPREHENSIVE SURVEY
KANAWHA RIVER BASIN
FLOOD CONTROL PROJECT
DEVELOPMENT AS OF JULY 1965
CORPS OF ENGINEERS U S ARMY OHIO RIVER DIVISION
APPENDIX M
FIGURE KA-1

8. Guyandotte River Basin

The Guyandotte River, located entirely within the State of West Virginia, is formed by the junction of the Winding Gulf and Stonecoal Creeks and flows northwesterly to enter the Ohio River at Huntington, West Virginia 676 miles above the mouth. The river valley is primarily rural and the flood plains of its main stem and tributaries are narrow and founded by steep slopes. Average annual precipitation is about 43.8 inches. Snowfall averages about 19.6 inches (unmelted) annually and is only a minor portion of the total precipitation. Average annual runoff is about 17.4 inches, with maximum and minimum values of 25.5 inches and 6.4 inches, respectively.

The January 1957 flood is the maximum flood of record on the main stem and the March 1963 flood established the record in many of the tributaries. A recurrence of a composite of the 1957 and 1963 floods would cause downstream damages of about $3.1 million and inundate 12,000 acres. Damages expected to occur from the modified 100-year flood would be 60 percent greater than the composite. (Table GU-1).

The July 1965 Federal flood control plan in the basin consists of one reservoir and one major local protection project, which will reduce damages in downstream areas to about $10,000 annually. Average annual damages in upstream areas are $1.3 million and have not been reduced due to the absence of upstream watershed projects. (Table GU-2 and Figure GU-1). The city of Logan, West Virginia, has been subject to damaging floods in the past. The R. D. Bailey Reservoir under preconstruction planning as of July 1965 will reduce future flooding at Logan, but will not eliminate the flood hazard to the community. There are no other major damage centers in the basin; however, the city of Mullins and the smaller communities of Oceana, Milton, Griffithsville, Yawkey, and Pineville are subject to damaging floods.

The city of Mullins is located on the right bank of the Guyandotte River about 158 miles upstream from the mouth, and along both banks of Slab Fork, a tributary which enters the Guyandotte River at Mullins. The main business district is located on the valley floor at the junction of the Guyandotte River and Slab Fork. The most practical plan would comprise channel widening of the Guyandotte River at Mullins. Such a plan has been considered but currently lacks economic feasibility. In the Griffithsville-Yawkey area a channel improvement project is under construction. For the remaining communities of Mullins, Oceana, Milton and Pineville which have flood problems it appears that channel improvements are the solution to the flood problems at these locations.

Downstream residual average annual damages have been projected to increase to about $41,000 annually by 2020. For the protection of several communities in the Guyandotte Basin, three major and two small local protection projects are included in the future flood control plan. For the control of Ohio River floods, ten reservoirs are included in the future plan. (Table GU-4 and Figure GU-1).

Average annual damages of $1.3 million in upstream areas are projected to increase to $2.1 million by 2020. (Table GU-3). Structural measures supplementing land treatment have been found potentially feasible in seven upstream watersheds. They consist of 19 miles of channel improvement and 27 retarding structures which could provide storages of 35,600 acre-feet for floodwater detention and 5,060 for sediment. (Table GU-4 and Figure GU-1). They would protect a drainage area of 525 square miles and their impoundments would control 190. The average annual flood damages occurring within the watersheds are estimated at $763,000 with more than 77 percent attributed to urban developments. The damage per square mile of their watershed area is estimated at $1,263. The potentially feasible projects would reduce average annual damages in upstream areas by $610,000. They would protect about 7,100 acres of flood plain and the improvements would enhance land values through an annual increase of $50,000 in productivity. The basin has over 80 percent of its land in forests, which through improvement and management could reduce flood damages.

As of September 1967, a flood plain information study is underway on Mud River at Milton.

Table GU-1

FLOOD PLAIN DATA - GUYANDOTTE RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

	Average Annual Damages ($1,000)		100 Year Modified Flood(1)		Composite Historical Flood(2)	
Category	Natural	Modified(1)	Area Inundated (Acres)	Damages ($1,000)	Area Inundated (Acres)	Damages ($1,000)
Agricultural Crop	Minor	Minor		Minor		Minor
Agricultural Non-Crop	Minor	Minor		Minor		Minor
Residential	248	Minor		2,619		1,071
Commercial	250	10		1,468		1,252
Industrial	Minor	Minor		Minor		Minor
Other(3)	133	Minor		888		776
TOTAL	631	10	15,000	4,975	12,000	3,099

B. UPSTREAM AREAS

	Average Annual Damages ($1,000)		100 Year Modified Flood(4)		
Category	Natural	Modified(4)	Category	Area Inundated (Acres)	Damages ($1,000)
Crop and Pasture	43	43	Crop		136
Other Agriculture	0	0	Non-Crop		0
Transportation Facilities	219	219	Residential		1,920
Urban	871	871	Commercial and Industrial		905
Sediment and Erosion	0	0	Other(3)		699
Indirect(5)	129	129			
TOTAL	1,262	1,262	TOTAL	18,540	3,660

NOTES:

(1) Modified by Projects in the July 1965 Flood Control Plan.

(2) Floods used for composite: January 1957, March 1963.

(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.

(4) Unmodified.

(5) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table GU-2

JULY 1965 FLOOD CONTROL PLAN

GUYANDOTTE RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
R. D. Bailey	AP	F,Q,R	540	203.7	22.0	0.8	181.7w[3]	6.3	169.5s[3]

B. UPSTREAM WATERSHED PROJECTS

None

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Floodwall	Channel	Other
Barboursville, W Va, Guyandotte River	UC	-	-	-	Bank stabilization

D. SMALL LOCAL PROTECTION PROJECTS

None

II. NON-FEDERAL

None

NOTES: (1) July 1965 Status: UC - Under construction AP - Authorized - advanced planning

(2) Purpose: F - Flood control Q - Water quality R - Recreation

(3) w - Winter s - Summer

Table GU-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

GUYANDOTTE RIVER BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	10	14	24	41
Upstream	1,262	1,394	1,672	2,085
Total Basin	1,272	1,408	1,696	2,126

Table GU-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

GUYANDOTTE RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Clear Fork	P	22	7.0	10.1
Tommy Creek	P	13	4.4	7.4
Pinnacle Creek	P	56	17.9	25.3
Rockcastle Creek	P	3	1.4	2.1
Indian Creek	P	34	10.9	15.7
Laurel Fork	P	47	15.0	21.3
Little Huff Creek	P	20	6.4	8.9
Barkers Creek	P	16	5.0	8.0
Marsh Fork	P	4	1.8	2.4
Mud River	I	270	84.1	90.3

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
7	525	27	'90	106,404	2,626	19

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Mullens, W Va, Guyandotte River	P	-	-	2.2
Pineville, W Va, Guyandotte River	P	-	-	1.8
Oceana, W Va, Clear Fork	P	-	-	5.0

D. SMALL LOCAL PROTECTION PROJECTS

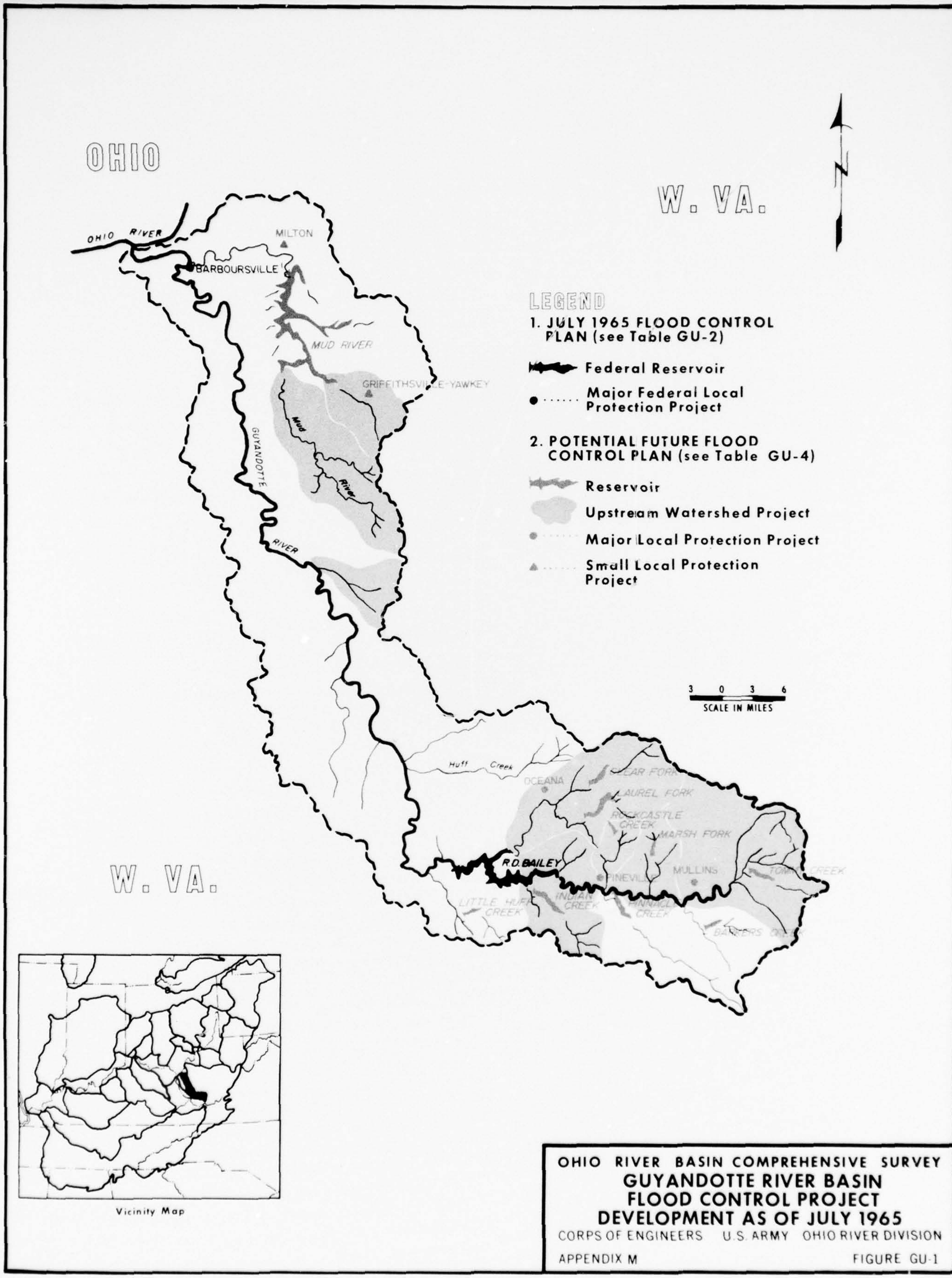
Project Location	Jul 65[1] Status	Remarks
Griffithsville-Yawkey, W Va, Middle Fork Mud River	P	Channel improvement
Milton, W. Va., Mud River	P	Channel improvement

NOTES:

(1) July 1965 Status

I - Authorized project - inactive status

P - Potential project



OHIO RIVER BASIN COMPREHENSIVE SURVEY
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9. <u>Big Sandy River Basin</u>

The Big Sandy River Basin lies within the states of Kentucky, West Virginia, and Virginia, and has a total drainage area of about 4,280 square miles. Most of the area is extremely rugged and only in the lower basin along the main stem of the Big Sandy River are the valleys relatively wide. The topography of the area contributes to the flood problems. The steep, narrow valleys of the upper basin have roads, railroads, mining and residential developments necessarily concentrated within the flood plain due to lack of terrain elsewhere that is suitable for such usage. Rapid rainfall runoff resulting from the mountainous terrain of the watershed produces flash floods characterized by swift, erratic fluctuations in stream level and high flood stages. Flood plain inundation occurs with inadequate warning time to permit removal of goods, furnishings, and equipment. The record basin-wide flood occurred in January 1957. Its recurrence would cause downstream damages of about $57.2 million if it were not for the intervening control works. Damages expected to occur from the modified 100-year flood would be about 1.2 times as much. (Table BS-1).

The July 1965 Federal flood control plan in the basin consists of four reservoirs, and one major and three small local protection projects. (Table BS-2 and Figure BS-1). In downstream areas average annual damages will be reduced from $3.3 million to $1.1 million, while in upstream areas damages have not been reduced due to the absence of upstream watershed projects. (Table BS-1). Martin, Kentucky is a major flood damage center with current annual losses of $169,000. Other major flood damage centers are Paintsville, and Inez, Kentucky; Grundy, Virginia; and Matewan and Williamson, West Virginia; with flood problems of a lesser nature at Pond Creek and South Williamson, Kentucky; and Berwind and Welch, West Virginia.

The town of Martin is located at the confluence of the Right and Left Forks of Beaver Creek. The town has been subjected to frequent headwater floods, backwater floods from Levisa Fork of the Big Sandy and combinations thereof. Although the Fishtrap and John W. Flannagan Reservoirs will practically eliminate backwater flooding, the town will still experience frequent headwater floods and damage. The only economically feasible and practical method for protection of Martin consists of a channel enlargement and realignment project. This project has recently been authorized.

Although the existing local protection has lessened the flood hazard at Williamson, serious damages are incurred during major flooding. With the potential Knox Creek and Panther Creek Reservoirs in operation the degree of protection at Williamson would double. Headwater flooding from Paint Creek at Paintsville will be eliminated by the recently authorized Paintsville Reservoir. However, Paintsville will still be subject to flooding from Levisa Fork. Major local protection projects have been previously studied at Welch and Matewan, West Virginia, Pond Creek, Kentucky, and Grundy, Virginia, and all lacked economic feasibility. At Inez, South Williamson, and Berwind small projects would

lessen the flood hazards. At Berwind, the project has been approved and construction is contingent upon completion of requirements for local cooperation. Two flood plain information studies are authorized as of September 1967 for the Grundy area on Levisa Fork and tributaries. In addition, studies have been authorized for the lower 30 miles of the Big Sandy River, and for Tug Fork at Williamson, West Virginia.

Tributary streams for which no economical solution of the flood control problems have been found under present conditions include Home, Slate, Parter, Garden, Russell Prater, and Indian Creeks, McClure River, Lick Creek and the South Fork of Pound River in the upper Levisa and Russell Fork areas and Dry Fork, Blackberry, Beech, Bens, Pigeon, Four Pole, Mate, Buffalo, Pond, and Big Creeks on the Tug Fork. In general, the improvements subject to flood damage are too scattered to permit justification of protection by levees, floodwalls, or channel improvement projects, and no economically feasible reservoir projects have been found.

Downstream residual average annual damages of $1.1 million have been projected to increase to about $4.7 million annually by 2020. (Table BS-3). To reduce these projected damages five reservoirs, and three major and five minor local protection projects have been included in a potential future flood control plan. (Table BS-4 and Figure BS-1).

Unmodified upstream annual damages of $1.6 million have been projected to increase to $2.6 million by 2020. (Table BS-3). Structural measures supplementing land treatment have been found to be potentially feasible in 20 upstream watersheds. (Table BS-4 and Figure BS-1). They consist of 41 miles of channel improvements and 82 retarding structures, which could provide storages of 110,700 acre-feet for floodwater detention and 15,000 for sediment. They cover a drainage area of 1,463 square miles and their impoundments would control 582 square miles. Average annual flood damages are estimated at $834,000 of which 68 percent are ascribed to urban developments. The damage per square mile of their watershed area is estimated at $570. The potentially feasible projects could reduce average annual damages in upstream areas by $667,000. They would protect about 21,900 acres of flood plain and the improvements would provide an opportunity to enhance land values an estimated $80,000 annually through an increase in productivity.

Table BS-1

FLOOD PLAIN DATA - BIG SANDY RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Historical Flood(2) Area Inundated (Acres)	Historical Flood(2) Damages ($1,000)
Agricultural Crop	57	18		Minor		Minor
Agricultural Non-Crop	Minor	Minor		Minor		Minor
Residential	950	330		20,850		16,459
Commercial	1,086	277		28,664		26,069
Industrial	Minor	Minor		Minor		Minor
Other(3)	1,232	439		17,223		14,684
TOTAL	3,325	1,064	35,000	66,737	27,000	57,212

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(4)
Crop and Pasture	213	213
Other Agriculture	20	20
Transportation Facilities	117	117
Urban	1,100	1,100
Sediment and Erosion	4	4
Indirect(5)	151	151
TOTAL	1,605	1,605

Category	100 Year Modified Flood(4) Area Inundated (Acres)	100 Year Modified Flood(4) Damages ($1,000)
Crop		702
Non-Crop		66
Residential		2,088
Commercial and Industrial		1,560
Other(3)		399
TOTAL	33,720	4,815

NOTES: (1) Modified by projects in the July 1965 Flood Control Plan.
(2) January 1957 flood.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Unmodified.
(5) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table BS-2

JULY 1965 FLOOD CONTROL PLAN

BIG SANDY RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Purpose (2)	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage		Flood Control Storage			
							Major Flood Season		Conservation Season	
					1,000 Ac Ft	Inches	1,000 Ac Ft	Inches	1,000 Ac Ft	
Dewey	C	F,R	207	33.3	12.3	1.1	81.0w (3)	7.3	76.1s (3)	
Fishtrap	UC	F,Q,R	395	164.4	10.5	0.5	153.8w	7.3	126.6s	
J. W. Flannagan	UC	F,Q,R	222	145.7	12.0	1.0	95.1w	8.7	78.6s	
N Fork Pound River	UC	F,R	18	11.3	1.9	2.0	9.4w	10.0	8.1s	

B. UPSTREAM WATERSHED PROJECTS

NONE

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles		
		Earth Levee	Concrete Flood Wall	Channel
Williamson, W Va, Tug Fork Big Sandy River	C	-	0.4	-

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles			
		Earth Levee	Concrete Flood Wall	Channel	Other
Prestonburg, Ky, Levisa Fork	C	Minor	-	-	Utilizes existing roadway fill
Snagging & Clearing Projects					
Langley, Ky, Right Fork, Beaver Creek	C				
Wayland-Garrett, Ky, Right Fork, Beaver Creek	C				

II. NON-FEDERAL

NONE

NOTES: (1) July 1965 Status: C - Completed UC - Under construction

(2) Purpose F - Flood control Q - Water quality R - Recreation

(3) w - Winter
s - Summer

Table BS-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

BIG SANDY RIVER BASIN

Area Location	Average Annual Damages ($1,000)			
	Residual	Projected		
	1965	1980	2000	2020
Downstream	1,064	1,523	2,658	4,660
Upstream	1,605	1,746	2,102	2,607
Total Basin	2,669	3,269	4,760	7,267

Table BS-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

BIG SANDY RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Paintsville	P	92	49.0	76.4
Yatesville	P	208	83.2	99.8
Panther Creek	P	24	10.1	16.9
Knox Creek (upper)	P	14	11.3	18.7
Knox Creek (lower) (2)	P	99 (3)	50.3	60.0
Haysi	I	88	42.5	68.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
20	1,463	82	582	303,616	10,121	41

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Martin, Ky, Beaver Creek	P	-	-	4.3
Pond Creek, Ky, Pond Creek	P	-	-	6.9
Matewan, W Va, Tug Fork & Mate Creek	P	0.8	-	-

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Remarks
South Williamson, Ky, Tug Fork	P	Earth levee
Inez, Ky, Rockcastle Creek	P	Channel improvement, Flood wall
Berwind, W Va, Dry Fork	P	Channel improvement
McDowell-Drift, Ky, Left Fork, Beaver Creek	P	Channel improvement
Meta, Ky, Johns Creek	P	Channel improvement

NOTES:

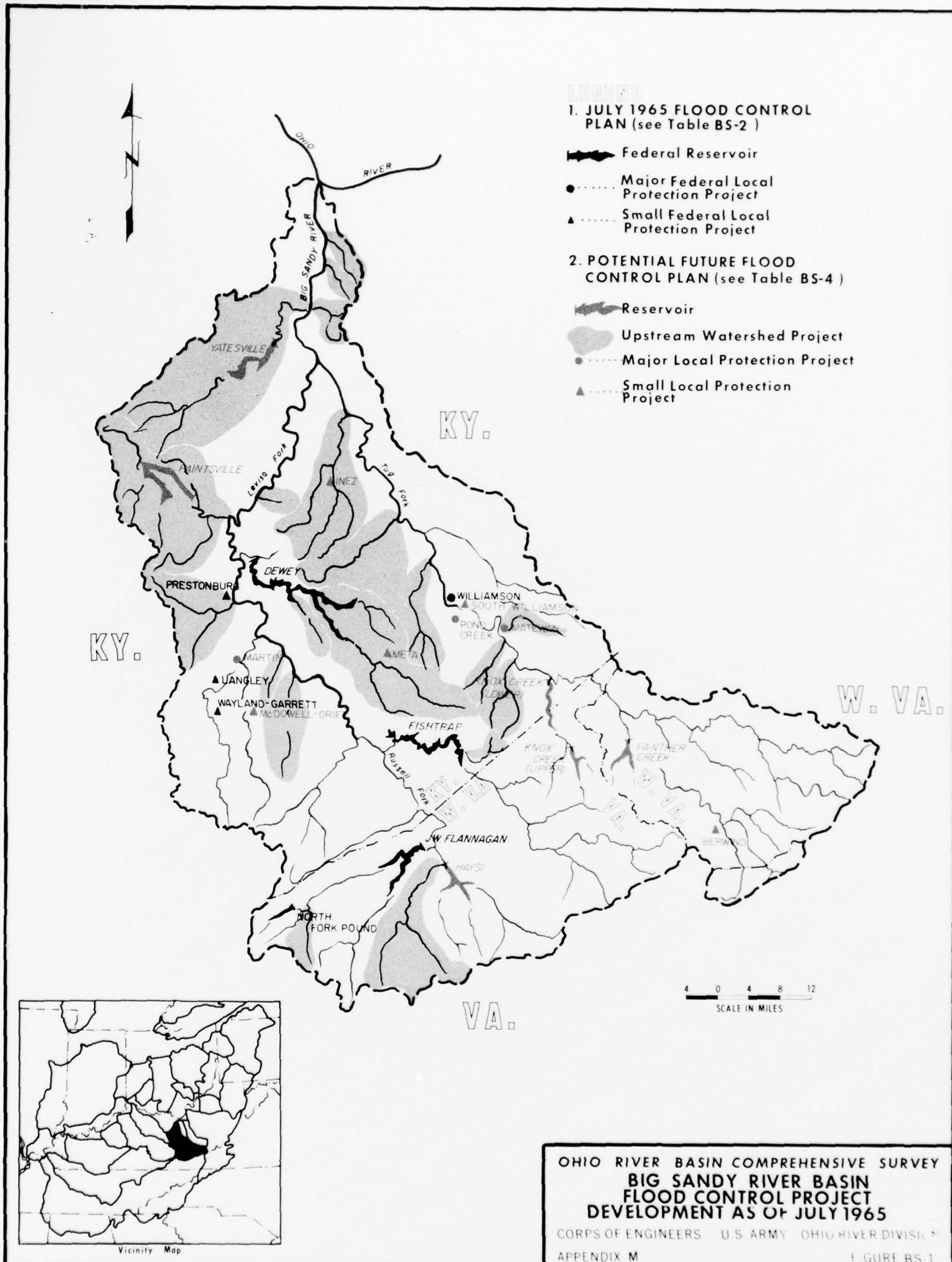
(1) July 1965 Status:

I - Authorized project - Inactive status

P - Potential project

(2) Alternate to upper site.

(3) Uncontrolled drainage area below upper site.



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10. Scioto River Basin

The Scioto River rises in northwestern Ohio and flows east 60 miles, then south 175 miles to join the Ohio River at Portsmouth, Ohio. The Scioto River valley is highly developed and has an above average density of population in the rural areas. The basin is situated entirely within the State of Ohio and has a drainage area of about 6,510 square miles. With the exception of the Gorge Section upstream from Columbus, the flood plain of the main stem is wide and fertile and largely subject to flooding. Average annual precipitation over the basin amounts to about 38 inches. Snowfall in the basin averages about 22 inches (unmelted) per annum and represents only a minor portion of the total annual precipitation. Basin runoff is highest during the winter months and lowest during the late summer and early fall. The average annual runoff for the basin is 11.6 inches with extremes ranging from 3.7 to 17.8 inches.

The basin has experienced numerous floods throughout its long period of streamflow records. The flood of March 1913 is the maximum of record on the Scioto River and major tributaries, with the exception of Alum and Big Walnut Creeks where the January 1959 flood caused flood stages in excess of those of March 1913. A recurrence of the January 1959 flood would cause $15 million in damages and inundate about 129,500 acres in downstream areas if it were not for the development of the intervening control works. In general, this amount of damage would be about equal to that of the modified 100-year flood. (Table SO-1).

The July 1965 Federal flood control plan in the basin consists of five reservoirs. In addition numerous private levees and a channel improvement project at Columbus have been constructed by local interests. (Table SO-2 and Figure SO-1). The flood control plan will reduce natural average annual flood damages in downstream areas from $4.5 to $4.0 million. (Table SO-1). The communities of Columbus, Chillicothe, LaRue, Kenton and Washington Court House are major damage centers. Flood problems of a lesser magnitude exist at Greencamp and Prospect. Frequent flooding of the rich agricultural areas bordering the main stem and major tributaries also presents a major problem throughout the basin.

The principal areas at Columbus which have been affected by major floods in the past are as follows: the west side lying along the right bank of the Scioto, the section along the Olentangy River near its confluence, and the east side along Alum and Big Walnut Creeks. Damages along the lower reach of the Olentangy River within the Columbus metropolitan area are minor due to the reductions effected by the completed Delaware Reservoir. Along the Scioto River the Mill Creek Reservoir along with existing non-Federal local protection works will practically eliminate damages on the west wide. On the east side, the multipurpose Alum Creek Reservoir would provide significant reductions in flood stages.

The city of Chillicothe is located on the right bank of the Scioto River, 69 miles above its mouth. The 1913 flood inundated seventy-five percent of the city and caused damages in excess of one million dollars. In addition, eighteen lives were lost as a direct result of this flood.

Photo 18. January 1959 Scioto River flood on east side of Chillicothe.

The five reservoirs in the July 1965 plan and the potential Alum and Mill Creek Reservoirs will reduce damages at Chillicothe. However, residual damages will remain relatively high even after these reservoirs are completed. Recently a local protection project was authorized and its construction is scheduled after the five reservoirs in the July 1965 plan and the Alum and Mill Creek reservoirs upstream are underway.

Local protection works would solve the flood problems at Kenton, La Rue, Greencamp, Prospect, and Washington Court House. However, at Kenton and Greencamp the costs of such projects would exceed the benefits. Kenton now has levees constructed by local interests that protect against moderately high water, but are overtopped in a major flood. At Prospect and La Rue protection works are economically justified, but lack local sponsorship requirements. At Washington Court House a channel improvement project was completed in October 1967.

Average annual downstream damages of $4 million have been projected to increase to $18 million by 2020, assuming further control and prevention measures are not implemented. (Table SO-3). In order to reduce projected downstream damages, five reservoir sites and six major and one small local protection project have been included in the potential future flood control plan. (Table SO-4 and Figure SO-1).

In upstream areas unmodified average annual damages of about $2 million have been projected to increase to $5.6 million by 2020. (Table

SO-3). There are 20 potentially feasible watershed projects in upstream areas that would contain about 3,129 square miles of drainage area, or almost 50 percent of the basin total and the impoundments would control about 449 square miles. (Table SO-4 and Figure SO-1). The potential projects consist of 497 miles of channel improvement and 85 retarding structures that could provide storages of 62,100 acre-feet for floodwater detention and 12,000 for sediment. The average annual flood damage occurring within these watersheds is $1.6 million, attributed as follows: 71.4 percent, agriculture; 1.6, transportation and facilities; and 27, urban developments. The damage per square mile of their watershed area is estimated at $507. The potentially feasible projects would reduce average annual damages in upstream areas by $1.3 million. They would protect about 76,400 acres of flood plain and their improvements would provide an opportunity for enhancing land values through an estimated annual $234,000 increase in productivity.

As of September 1967, flood plain information studies have been completed on the Scioto and Olentangy Rivers from Delaware Dam to Circleville and at Chillicothe. Other studies are underway along Alum Creek from the potential Alum Creek Reservoir to its mouth and on Big Walnut Creek, from its mouth to Hoover Reservoir.

Due to the scarcity of available large reservoir sites, it appears that small reservoirs, watershed projects, channel improvements, and urban and rural levees are practical solutions to the remaining flood problems. Flood plain zoning could avoid the creation of future problems.

Table SO-1

FLOOD PLAIN DATA - SCIOTO RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Historical Flood(2) Area Inundated (Acres)	Historical Flood(2) Damages ($1,000)
Agricultural Crop	879	683		3,082		3,124
Agricultural Non-Crop	134	84		269		310
Residential	471	403		5,235		5,478
Commercial	234	205		2,490		2,585
Industrial	184	168		1,216		1,492
Other(3)	2,632	2,499		3,135		3,375
TOTAL	4,534	4,042	125,000	15,427	129,500	15,054

B. UPSTREAM AREAS

Average Annual Damages ($1,000)

Category	Natural	Modified(4)
Crop and Pasture	1,181	1,181
Other Agriculture	96	96
Transportation Facilities	34	34
Urban	452	452
Sediment and Erosion	23	23
Indirect(5)	179	179
TOTAL	1,965	1,965

100 Year Modified Flood(4)

Category	Area Inundated (Acres)	Damages ($1,000)
Crop		6,495
Non-Crop		530
Residential		1,035
Commercial and Industrial		1,450
Other(3)		315
TOTAL	96,440	9,825

NOTES:
(1) Modified by projects in the July 1965 Flood Control Plan.
(2) January 1959 flood.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Unmodified.
(5) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table SO-2

JULY 1965 FLOOD CONTROL PLAN

SCIOTO RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65 Status(1)	Purpose(2)	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Delaware	C	F,Q,R	381	132.0	8.4	0.4	132.6w(3)	6.1	118.0s(3)
Big Darby	UC	F,R	448	129.0	7.3	0.3	121.6	5.1	121.6
Deer Creek	UC	F,R	278	102.5	6.4	0.4	96.1w	6.5	81.5s
Paint Creek	UC	F,R	573	145.0	8.9	0.3	136.1	4.5	136.1
Salt Creek	AP	F,R	285	100.3	6.3	0.4	94.0w	6.2	88.3s

B. UPSTREAM WATERSHED PROJECTS

NONE

C. MAJOR LOCAL PROTECTION PROJECTS

NONE

D. SMALL LOCAL PROTECTION PROJECTS

NONE

II. NON-FEDERAL

A. RESERVOIRS

NONE

B. LOCAL PROTECTION PROJECTS

Project Location	Status(4)	Remarks
Columbus, Scioto River	C	Channel Improvements completed by the City of Columbus
Blacklick Estates Levees, Blacklick Creek	C	Completed by private corporation

NOTES: (1) July 1965 Status: C - Completed UC - Under construction AP - Authorized - advanced planning

(2) Purpose: F - Flood control Q - Water quality R - Recreation

(3) w - Winter s - Summer

(4) Status of non-Federal projects as shown in Appendix J "State Laws, Policies and Programs," Ohio River Basin Comprehensive Survey
C - Completed

Table SO-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

SCIOTO RIVER BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	4,042	6,443	9,800	17,552
Upstream	1,965	2,829	4,181	5,585
Total Basin	6,007	9,272	13,981	23,137

Table SO-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

SCIOTO RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Alum Creek	A	123	47.5	124.0
Mill Creek	A	181	88.5	92.5
Upper Darby	P	239	7.0	32.5
Roundhead	P	34	11.0	11.9
Bellepoint	P	736 (2)	85.0	88.2

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
20	3,129	85	449	277,475	10,607	497

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles		
		Earth Levee	Concrete Flood Wall	Channel
Chillicothe, Ohio, Scioto River	A	0.4	1.2	-
Chillicothe, Ohio, Paint Creek	P	1.0	0.5	-
Prospect, Ohio, Scioto River	P	1.2	0.2	-
LaRue, Ohio, Scioto River	P	2.3	0.6	-
Greencamp, Ohio, Scioto & Little Scioto River	P	0.5	-	-
Kenton, Ohio, Scioto River	P	2.4	-	-

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Remarks
Washington Court House, Ohio, Paint Creek	P	Channel Improvement

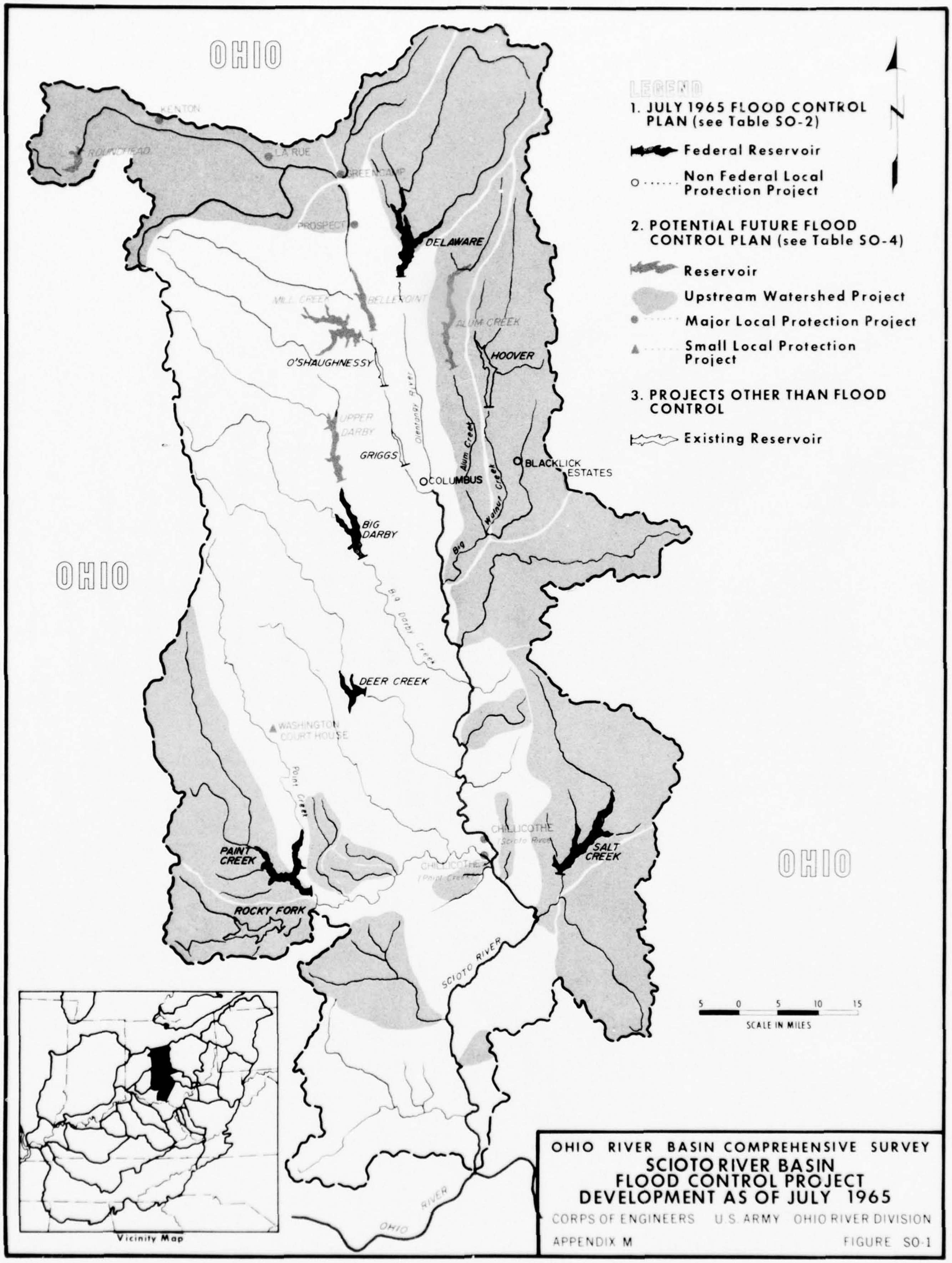
NOTES:

(1) July 1965 Status

A - Authorized project - Active Status

P - Potential project

(2) Uncontrolled drainage area below Roundhead Reservoir.



OHIO RIVER BASIN COMPREHENSIVE SURVEY

SCIOTO RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE SO-1

11. <u>Little Miami River Basin</u>

The Little Miami River Basin, situated in the southwestern portion of Ohio, is roughly pear-shaped with the large end near the mouth and drains an area of approximately 1,760 square miles. The Little Miami River has its headwaters near Springfield in Clark County and enters the Ohio River just east of Cincinnati. The basin has a mean annual rainfall of about 40 inches. While generally the southern part of the basin receives more rainfall than the northern portion, annual precipitation in excess of 60 inches has been recorded in some sections of the basin.

The Little Miami Basin is seriously affected by major floods, such as those occurring in 1913, 1933, 1937, 1940, 1945, 1959, 1963 and 1964. Extensive damage in the lower basin below Milford is caused by backwater from the Ohio River, as in the 1937 flood. The January 1959 flood was the second highest of record on the Little Miami River, exceeded only by the flood of 1913. Flooding of some tributaries reached record proportions and flash flooding of some streams caused widespread damage. A recurrence today of the January 1959 flood would cause $8.4 million in downstream damages and flood almost 9,000 acres. It would exceed the damage expected from the 100-year modified flood by 70 percent and would inundate almost twice the area. (Table LM-1)

Photo 19. East Loveland Avenue, Loveland, Ohio, during January 1959 flood.

The July 1965 Federal flood control plan in the basin consists of East Fork and Caesar Creek Reservoirs which control the runoff from 579 square miles. Local interests (City of Cincinnati) have completed a levee at Lunken Airport to provide protection from Ohio River backwater flooding. (Table LM-2 and Figure LM-1).

This flood control plan will reduce natural average annual damages in downstream areas from $1.3 million to $310,000. (Table LM-1). In upstream areas damages have not been reduced, since there are no authorized watershed projects. There are no major damage centers in the basin. However, numerous towns and villages such as Morrow, South Lebanon, Loveland, and Milford sustain damages. Additional reservoirs on major tributaries could further decrease immediate flood problems along the Little Miami main stem. Levee units are generally not feasible because of the narrow valleys. Flood plains in the upper portion and along most tributaries are developing rapidly, particularly near small towns, developing future problem areas. A flood plain information study has been completed from Morrow to the mouth of the Little Miami River.

Downstream residual average annual damages of $310,000 have been projected to increase to $1.4 million by 2020 assuming further control and prevention measures are not implemented. (Table LM-3). Included in the potential future flood control for downstream areas are four reservoirs. (Table LM-4 and Figure LM-1).

In upstream areas unmodified average annual damages of $412,000 are projected to increase to $1.2 million by 2020. (Table LM-3). Structural measures supplementing land treatment are potentially feasible in six upstream watersheds. (Table LM-4 and Figure LM-1). These would comprise 853 square miles or 43 percent of the drainage area. They consist of 200 miles of channel improvement and 36 retarding structures which could provide storages of 28,493 acre-feet for floodwater detention and 5,000 for sediment. They would control about 203 square miles of drainage area and would protect 19,482 acres of flood plain. The average annual flood damages within these potential project watersheds are estimated at $339,000 attributed as follows: 81 percent, agriculture; 2, transportation, and 17, urban developments. The damage per square mile of their watershed area is estimated at $397. The projects would reduce average annual damages in upstream areas by $271,000. Their improvements would provide an opportunity for enhancing land values through an estimated $168,000 annual increase in productivity.

Table LM-1

FLOOD PLAIN DATA - LITTLE MIAMI RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Historical Flood(2) Area Inundated (Acres)	Historical Flood(2) Damages ($1,000)
Agricultural Crop	35	Minor		49		56
Agricultural Non-Crop	35	5		47		110
Residential	750	163		2,605		4,096
Commercial	285	86		1,298		1,891
Industrial	11	Minor		80		1,095
Other(3)	205	56		801		1,166
TOTAL	1,321	310	4,730	4,880	8,970	8,414

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(4)
Crop and Pasture	274	274
Other Agriculture	23	23
Transportation Facilities	5	5
Urban	67	67
Sediment and Erosion	5	5
Indirect(5)	38	38
TOTAL	412	412

Category	100 Year Modified Flood(4) Area Inundated (Acres)	100 Year Modified Flood(4) Damages ($1,000)
Crop		903
Non-Crop		75
Residential		93
Commercial and Industrial		132
Other(3)		33
TOTAL	23,000	1,236

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) January 1959 flood.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Unmodified.
(5) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table LM-2

JULY 1965 FLOOD CONTROL PLAN

LITTLE MIAMI RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Purpose (2)	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Caesar Creek	AP	F,M,Q,R	237	242.2	13.3	1.0	148.5w (3)	11.7	140.2s (3)
East Fork	AP	F,M,Q,R	342	294.8	19.0	1.0	210.6w	11.6	118.0s

B. UPSTREAM WATERSHED PROJECTS

NONE

C. MAJOR LOCAL PROTECTION PROJECTS

NONE

D. SMALL LOCAL PROTECTION PROJECTS

NONE

II. NON-FEDERAL

A. RESERVOIRS

NONE

B. LOCAL PROTECTION PROJECTS

Project Location	Status	Remarks
Lunken Airport Levee, Little Miami & Ohio Rivers	C	Constructed by the City of Cincinnati

NOTES: (1) July 1965 Status: AP - Authorized - Advanced planning

(2) Purpose: F - Flood control M - Water supply R - Recreation Q - Water quality

(3) w - Winter
s - Summer

Table LM-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

LITTLE MIAMI RIVER BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	310	543	917	1,402
Upstream	412	630	926	1,237
Total Basin	722	1,173	1,843	2,639

Table LM-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

LITTLE MIAMI RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Todd Fork	P	245	82.0	95.0
Washington Mills	P	308	45.0	61.0
Cowan Creek	P	51	12.0	14.0
Morrow	P	685	208.0	244.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
6	853	36	203	86,171	4,272	200

C. MAJOR LOCAL PROTECTION PROJECTS

None defined at present

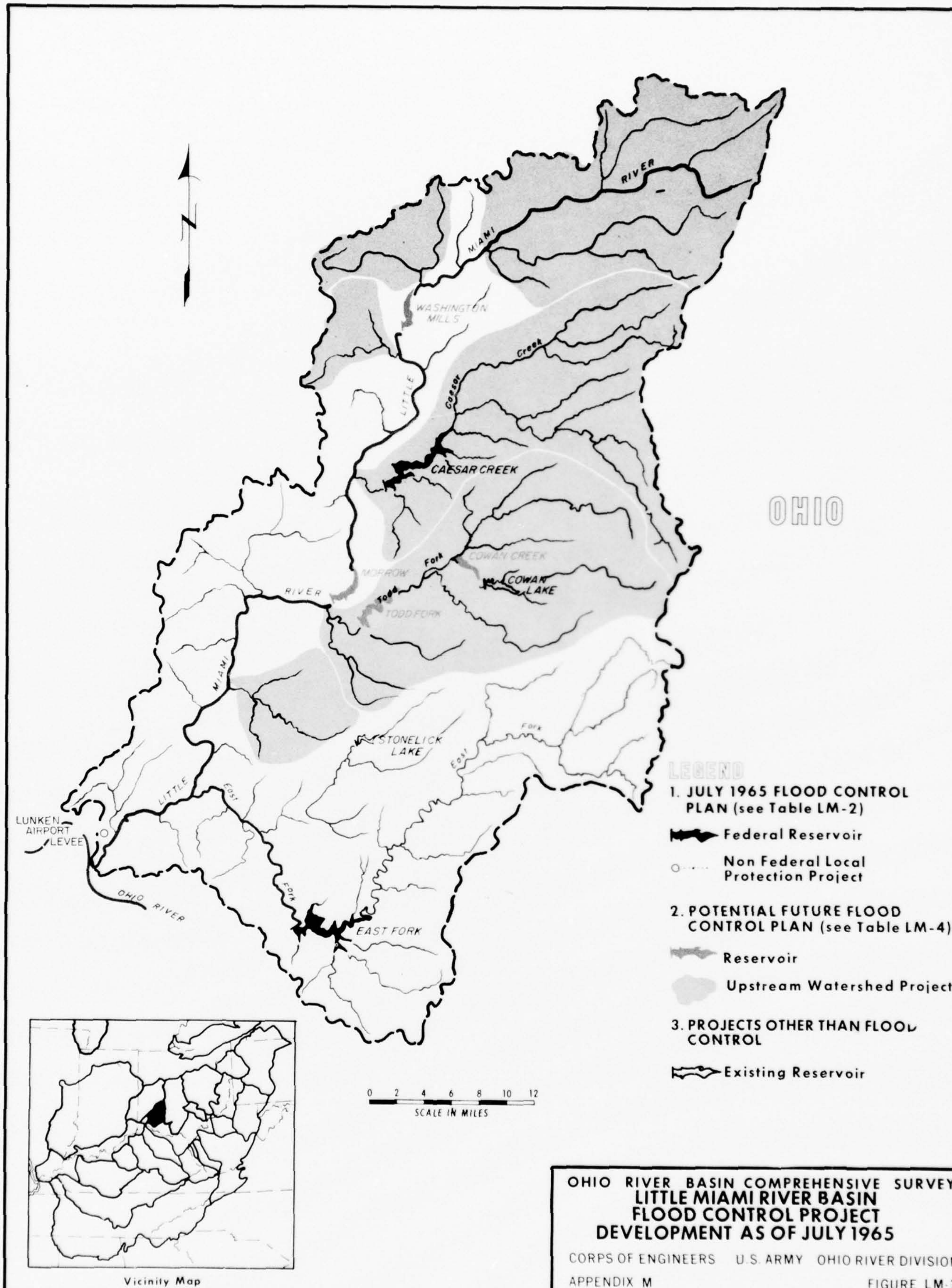
D. SMALL LOCAL PROTECTION PROJECTS

None defined at present

NOTE:

(1) July 1965 Status

P - Potential project



OHIO RIVER BASIN COMPREHENSIVE SURVEY
LITTLE MIAMI RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965
CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION
APPENDIX M FIGURE LM-1

12. Great Miami River Basin

The Great Miami River is formed in Logan County, Ohio, then flows in a southwesterly direction, emptying into the Ohio River at the extreme southwest corner of the state. The basin includes portions of southwestern Ohio and southeastern Indiana and drains approximately 5,400 square miles. Above Dayton, Ohio, the valleys are narrow and comparatively shallow, whereas below Dayton the valleys are broad and comparatively open. Average annual precipitation in the basin is about 40 inches.

The March 1913 flood caused 300 persons to lose their lives and extensive property damage. Those cities in the basin which sustained the heaviest damages were Dayton, Hamilton, Piqua, Troy, Middletown, Franklin and Miamisburg, Ohio. A recent major flood of record occurred in January 1959, and in some parts of the basin, record stages set by the 1913 flood were exceeded. A composite of these floods would inflict about $27 million in downstream damages and inundate over 82,000 acres if it were not for the intervening control works. Its damaging effect would be almost three times as great as that of the modified 100-year flood. (Table GM-1).

The major basin flood control works are those constructed and maintained by the Miami Conservancy District. The District, a political subdivision of the State of Ohio, was formed following the March 1913 flood and has powers such as eminent domain and raising funds by special assessment. The original District works were constructed between 1918 and 1922, and they provide urban areas with protection from flood flows equivalent to 40 percent above that of the 1913 flood.

The District's works include five retarding basins with a total storage capacity of 841,000 acre-feet reserved for flood control, 53 miles of levees, and maintenance of approximately 43 miles of channel improvements through urban areas. The retarding basins are Lockington, in the upper basin on Loramie Creek above Piqua; Englewood, on Stillwater River; Taylorsville, on Great Miami River; and Huffman, on Mad River. These reservoirs control 97 percent of the drainage area above Dayton. The Germantown project is on Twin Creek, a tributary entering the main stem between Franklin and Middletown. Their storage is controlled by ungated outlets at each dam. The District's local protection works supplement the retarding basins. The original local protection works provided protection to 9,600 acres of urban areas. Five additions at Dayton, Miamisburg and Middletown have added 2,100 acres for a total of 11,700 acres of protected area. Local protection is now provided at Piqua, Troy, Tipp City, Miami Villa, Dayton, Moraine, West Carrollton, Miamisburg, Franklin, Middletown, Dicks Creek, and Hamilton, Ohio. (Table GM-2 and Figure GM-1).

In addition to the District's control works the July 1965 Federal flood control plan in the basin consists of two reservoirs and two upstream watershed projects. (Table GM-2 and Figure GM-1). Clarence J. Brown Reservoir, included in the July 1965 plan, is above Huffman Dam,

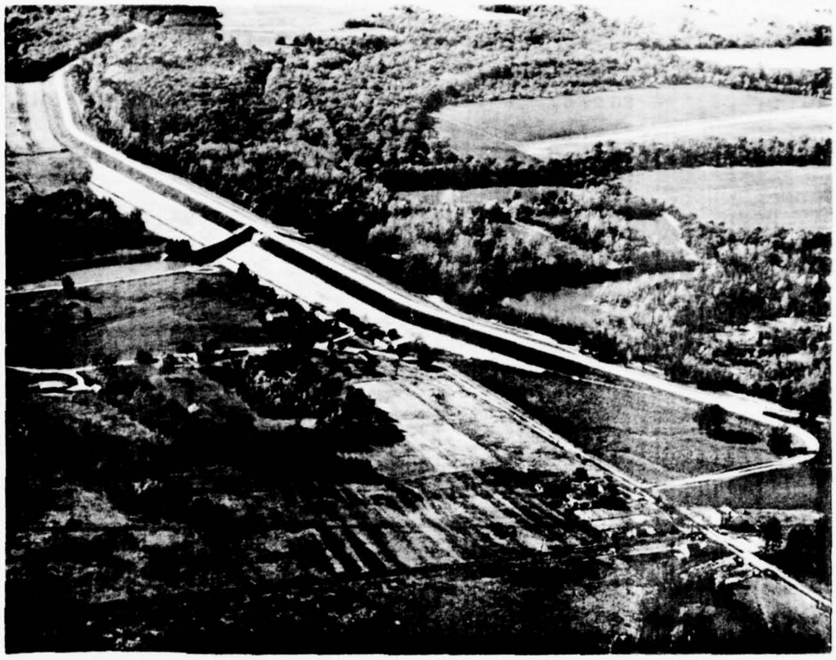


Photo 20. Lockington Dam, one of Miami Conservancy District's retarding basins.

one of the Conservancy District's structures. It will essentially eliminate flooding on Buck Creek through Springfield and reduce stages on the lower Mad River above Huffman. When this structure is completed, it is estimated that remaining annual downstream damages along the Great Miami and tributaries, excluding the Whitewater River Basin, will be reduced to about $1.5 million.

Brookville Reservoir, also included in the plan on the East Fork of the Whitewater, will control about 25 percent of that river's drainage area. Due to its location, it will reduce damages along the Whitewater by 40 percent, or to about $200,000 annually.

East Fork Buck Creek, Champaign County, and Dicks Creek-Little Muddy Creek, Butler and Warren counties, Ohio are the only authorized watershed projects in the basin. They will protect 80 square miles with land treatment, provide 11 floodwater retarding structures and 21 miles of channel improvement. The flood control cost of the structural measures amounts to $1.6 million and they will prevent $91,000 in annual damages on 2,650 acres.

Although there has been a significant reduction in flood damages in the basin, the flood plains are developing rapidly and it is believed that

the flood hazard will significantly increase. Immediate flood prevention objectives should include treatment of local problems as they become apparent, and use of flood zoning in critical areas. In addition, multipurpose reservoirs may be considered as water resource needs become more acute.

In downstream areas average annual damages of $1.7 million have been projected to increase to $7.7 million, assuming further control and prevention measures are not implemented. (Table GM-3) Included in the potential future flood control plan for downstream areas are six reservoirs and one small local protection project. (Table GM-4 and Figure GM-1).

In upstream areas average annual damages of $2.2 million have been projected to increase to $6.2 million. (Table GM-3). There are 17 potentially feasible watershed projects in upstream areas, consisting of 507 miles of channel improvement and 116 retarding structures, which could provide storages of 97,900 acre-feet for floodwater detention and 18,200 for sediment. (Table GM-4 and Figure GM-1). These would provide protection for 3,214 square miles and the structures would control 702 square miles of drainage area. The average annual flood damages are estimated at $1.8 million with more than 66 percent attributed to agriculture and 31 percent to urban developments. The damage per square mile of their watershed area is estimated at $558. The projects would reduce average annual damages in upstream areas by $1.4 million. They would protect about 76,210 acres of flood plain and their improvements provide an opportunity for enhancing land values through an estimated annual $341,000 increase in productivity.

The Miami Conservancy District encourages zoning and makes flood plain information available to local governmental units. Three counties, Montgomery, Butler, and Hamilton and numerous townships and cities have flood plain regulations in their zoning ordinances. The ultimate goal of these regulations is to prevent developments in the flood plains that would obstruct flows or would incur serious damages.

A flood plain information study is underway as of September 1967 on the East Fork of the Whitewater River at Columbus, Indiana.

Table GM-1

FLOOD PLAIN DATA - GREAT MIAMI RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural(1)	Average Annual Damages ($1,000) Modified(2)	100 Year Modified Flood(2) Area Inundated (Acres)	100 Year Modified Flood(2) Damages ($1,000)	Composite Historical Flood(3) Area Inundated (Acres)	Composite Historical Flood(3) Damages ($1,000)
Agricultural Crop	123	60		64		320
Agricultural Non-Crop	240	120		646		2,341
Residential	1,490	807		6,194		10,536
Commercial	581	303		1,784		3,482
Industrial	171	67		1,038		5,539
Other(4)	552	293		1,447		5,165
TOTAL	3,157	1,650	31,520	11,173	82,120	27,383

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(2)
Crop and Pasture	1,210	1,167
Other Agriculture	80	79
Transportation Facilities	147	145
Urban	616	584
Sediment and Erosion	19	15
Indirect(5)	202	193
TOTAL	2,274	2,183

Category	100 Year Modified Flood(2) Area Inundated (Acres)	100 Year Modified Flood(2) Damages ($1,000)
Crop		3,852
Non-Crop		261
Residential		1,041
Commercial and Industrial		867
Other(3)		528
TOTAL	94,480	6,549

NOTES: (1) Residual damages after stage reduction and protection by the Miami Conservancy District flood protection works.
(2) Modified by projects in the July 1965 flood control plan.
(3) Floods used for composite: March 1913, January 1959.
(4) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(5) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

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Table GM-2

JULY 1965 FLOOD CONTROL PLAN

GREAT MIAMI RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Brookville	UC	F,M,R	379	359.6	55.6	4.9	214.7w[3]	10.6	175.6s[3]
Clarence J. Brown	UC	F,Q,R	82	63.7	9.9	2.1	32.9w	7.5	26.8s

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose[4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Dick's Cr-Little Muddy Cr, Ohio	FP	69.7	6	22.4	184	5,161		5,345	17.7
East Fork Buck Cr, Ohio	FP,F&WL	10.3	5	3.0	82	289	101	472	3.7

C. MAJOR LOCAL PROTECTION PROJECTS

None

D. SMALL LOCAL PROTECTION PROJECTS

None

II. NON-FEDERAL

A. RETARDING BASINS[5]

Retarding Basin	Jul 65[1] Status	Purpose[2]	Capacity[6] (1,000 Ac Ft)
Englewood	C	F	312
Germantown	C	F	106
Huffman	C	F	167
Taylorsville	C	F	186
Lockington	C	F	70

B. LOCAL PROTECTION PROJECTS[5]

Project Location	Jul 65[1] Status	Type of Project & Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Piqua, Ohio, Miami River	C	2.8	-	3.0
Troy, Ohio, Miami River	C	3.5	-	2.2
Tipp City, Ohio, Miami River	C	1.2	-	-
Miami Villa, Ohio, Miami River	C	0.8	-	0.5
Dayton, Ohio, Miami River	C	17.6	-	10.5
Moraine, Ohio, Miami River	C	2.5	-	5.0
West Carrollton, Ohio, Miami River	C	2.4	-	-
Miamisburg, Ohio, Miami River	C	4.0	-	3.0
Franklin, Ohio, Miami River	C	3.7	-	1.7
Middletown, Ohio, Miami River	C	9.6	-	8.4
Dicks Creek, Ohio	C	-	-	4.4
Hamilton, Ohio, Miami River	C	5.1	-	3.8

NOTES: (1) July 1965 Status: C - Completed UC - Under construction

(2) Purpose: F - Flood control M - Water supply R - Recreation
Q - Water quality

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention F&WL - Fish and wildlife development

(5) Projects constructed by the Miami Conservancy District.

(6) Capacity exclusively for flood control.

Table GM-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

GREAT MIAMI RIVER BASIN

Area Location	Average Annual Damages ($1,000) Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	1,650	2,967	4,624	7,732
Upstream	2,183	3,245	4,684	6,220
Total Basin	3,833	6,212	9,308	13,952

Table GM-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

GREAT MIAMI RIVER BASIN

A. RESERVOIRS

Reservoir	1 Jul 65(1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1,000 Ac Ft)	Total Storage (1,000 Ac Ft)
Oldenburg	P	80	54.4	63.0
Pipe Creek	P	66	65.7	68.3
Blue Creek	P	26	28.8	29.0
Williams Creek	P	28	25.4	28.5
Dry Fork	P	45	34.6	37.0
Duck Creek	P	25	16.7	18.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (acres)	Estimated Flood Channel Improvements (Miles)
17	3,214	116	702	225,878	11,826	507

C. MAJOR LOCAL PROTECTION PROJECTS

None defined at present

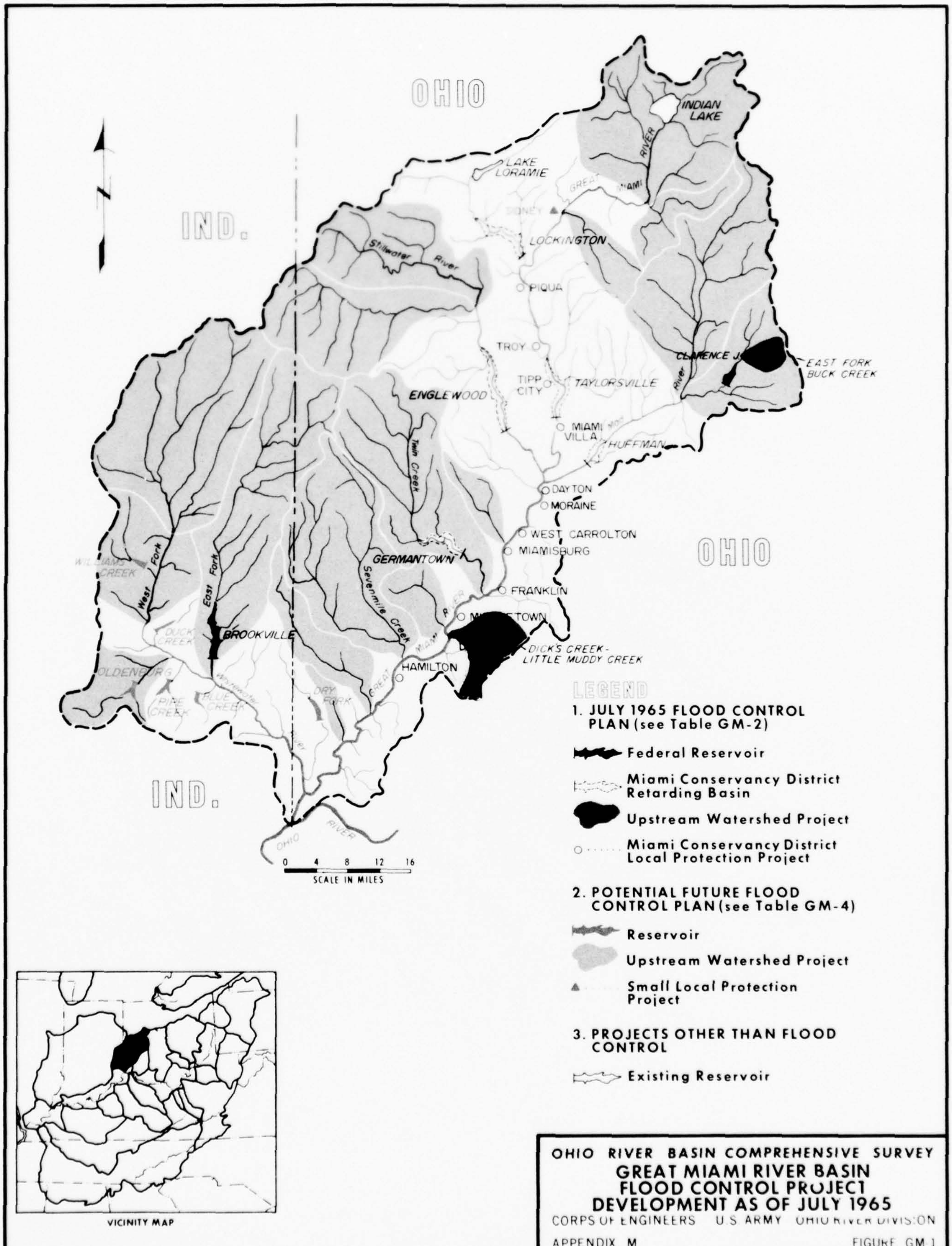
D. SMALL LOCAL PROTECTION PROJECTS

Project Location	1 Jul 65(1) Status	Remarks
Sidney, Ohio, Great Miami River	P	Earth Levee

NOTE:

(1) July 1965 Status

P - Potential project



OHIO RIVER BASIN COMPREHENSIVE SURVEY

GREAT MIAMI RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE GM-1

13. Licking River Basin

The Licking River rises in the Cumberland Mountains in eastern Kentucky and flows in a general northwesterly direction for a distance of about 320 miles to enter the Ohio River from the left bank opposite Cincinnati, Ohio, 511 miles above the mouth of the Ohio. For the greater part, the flood plain of the Licking River is comparatively narrow, averaging about one-fourth mile in width. However, in some sections, notably in the reach extending from Mile 190 above the mouth downstream to about Mile 150, the average width of the flood plain is about one mile. The basin has an area of approximately 3,670 square miles and lies wholly within the Commonwealth of Kentucky. As a whole, the basin is hilly to mountainous, except the area near the head of South Fork, which is rolling. In the upper basin area, the topography is rugged and no flat land exists except in the narrow river bottoms. Since the basin is rural in character, agriculture predominates except in the Newport-Covington area near the river mouth, where industry predominates.

The March 1964 flood caused $2.6 million damages, and was the maximum of record at many points in the basin. At Falmouth, the crest reached 47 feet as compared with the previous record of 41.6 in 1948. A recurrence of a composite of record floods would inflict $6.1 million in damages today and flood more than 41,000 acres of downstream areas. In comparison, the modified 100-year flood would cause damages of about $10.6 million. (Table LI-1).

The July 1965 Federal flood control plan in the basin consists of the Cave Run Reservoir and one upstream watershed project. (Table LI-2 and Figure LI-1). The Cave Run Reservoir will reduce downstream annual damages from $1.1 million to about $660,000 and control approximately 20 percent of the drainage area. (Table LI-1). Twin Creek, Harrison County, is the only authorized watershed project. It has 2 floodwater retarding structures and 3.7 miles of channel improvements which protect 817 acres of flood plain. The flood prevention cost of the structures is $42,000.

One of the principal areas in the Licking River Basin affected by periodic floods is in the reach of valley between Mile 105 and Mile 190 above the mouth. Records indicate that damaging cropping season floods occur on an average of once in less than two years. Major urban flood problem areas are at Salyersville and Falmouth. Other problems areas are at Cynthiana and Morehead. In addition to local flood problems within the Licking Basin, the Licking River is a principal contributor to major floods on the Ohio River at and below the Cincinnati area.

Salyersville is located on the Licking River at Mile 270, Magoffin County. A local flood protection project for Salyersville was authorized by the 1941 Flood Control Act. However, local interests objected to the authorized plan on the basis that it leaves large sections of Salyersville unprotected and that too much space is required for construction purposes. In addition, because of financial incapabilities, local interests have not been able to meet sponsorship requirements. Royalton Reservoir, included in the potential future plan, would provide some relief to Saylersville.

Falmouth is located just above the junction of the South Fork and the Licking River. The Falmouth Reservoir included in the potential future flood control plan would virtually eliminate flood damages at Falmouth and reduce damages on the Licking River downstream to the mouth. However, local problem areas would remain in the basin. The South Fork, which includes Cynthiana, will sustain the most residual damage. Recent studies indicate that a large portion of its damages could be alleviated by a reservoir on Hinkston Creek, a South Fork tributary. Presently, this reservoir lacks local support. A channel improvement plan for Morehead on Triplett Creek is under study and may be constructed in the near future.

In downstream areas 1965 average annual damages of $660,000 are projected to increase to $1.9 million by 2020. (Table LI-3). Included in the potential future flood control plan for downstream areas are three reservoirs, and one major and one small local protection project. (Table LI-4 and Figure LI-1).

In upstream areas annual damages of $664,000 have been projected to increase to $1.2 million by 2020. (Table LI-3). Structural measures supplementing land treatment have been found potentially feasible in nine additional upstream watersheds. (Table LI-4 and Figure LI-1). They consist of 48 miles of channel improvement and 65 retarding structures which could provide storages of 82,088 acre-feet for floodwater detention and 13,250 for sediment. These projects would cover about 1,000 square miles of drainage area and the structures control about 500 square miles. The average annual flood damages occurring within these watersheds are estimated at $615,000 primarily to agriculture crops; however, some urban damage occurs. The damage per square mile of their watershed area is estimated at $613. The projects would reduce average annual damages in upstream areas by $492,000. They would protect about 29,000 acres of flood plain and their improvements would provide an opportunity for enhancing land values through an estimated annual $343,000 increase in productivity.

Due to the agrarian nature of this mountainous basin, it is believed that future flood problems, with the exception of the South Fork, will be confined to localized areas. As of September 1967 a flood plain information study is underway on the lower portion of the Licking River in Boone and Kenton Counties.

Table LI-1

FLOOD PLAIN DATA - LICKING RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Composite Historical Flood(2) Area Inundated (Acres)	Composite Historical Flood(2) Damages ($1,000)
Agricultural Crop	452	241		391		421
Agricultural Non-Crop	117	67		552		289
Residential	232	153		3,338		2,538
Commercial	130	89		2,939		1,796
Industrial	17	17		434		160
Other(3)	156	93		2,917		887
TOTAL	1,104	660	35,290	10,571	41,410	6,091

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)
Crop and Pasture	432	430
Other Agriculture	35	35
Transportation Facilities	29	29
Urban	103	103
Sediment and Erosion	8	8
Indirect(4)	59	59
TOTAL	666	664

Category	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)
Crop		1,372
Non-Crop		113
Residential		191
Commercial and Industrial		131
Other(3)		119
TOTAL	31,860	1,926

NOTES:
(1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: January-February 1937, February 1939, April 1948, March 1964.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table LI-2

JULY 1965 FLOOD CONTROL PLAN

LICKING RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Cave Run	UC	F,Q,R	826	614.1	147.3	3.5	438.5w[3]	10.0	391.5s[3]

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose[4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Twin Creek, Ky	FP	27.2	2	1.7	35	330	-	365	3.7

C. MAJOR LOCAL PROTECTION PROJECTS

None

D. SMALL LOCAL PROTECTION PROJECTS

None

II. NON-FEDERAL

None

NOTES: (1) July 1965 Status: UC - Under construction

(2) Purpose: F - Flood control Q - Water quality R - Recreation

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention

Table LI-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

LICKING RIVER BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	660	979	1,399	1,919
Upstream	664	793	977	1,165
Total Basin	1,324	1,772	2,376	3,084

Table LI-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

LICKING RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65(1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Falmouth	A	1,505(2)	648.6	898.3
Hinkston Creek	P	174	97.6	128.0
Royalton	P	76	32.9	47.3

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
9	1,003	65	502	294,544	11,740	48

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65(1) Status	Type of Project and Length in Miles		
		Earth Levee	Concrete Flood Wall	Channel
Salyersville, Ky, Licking River	D	0.9	0.1	-

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65(1) Status	Remarks
Morehead, Ky, Triplett Creek	P	Channel improvement

NOTES:

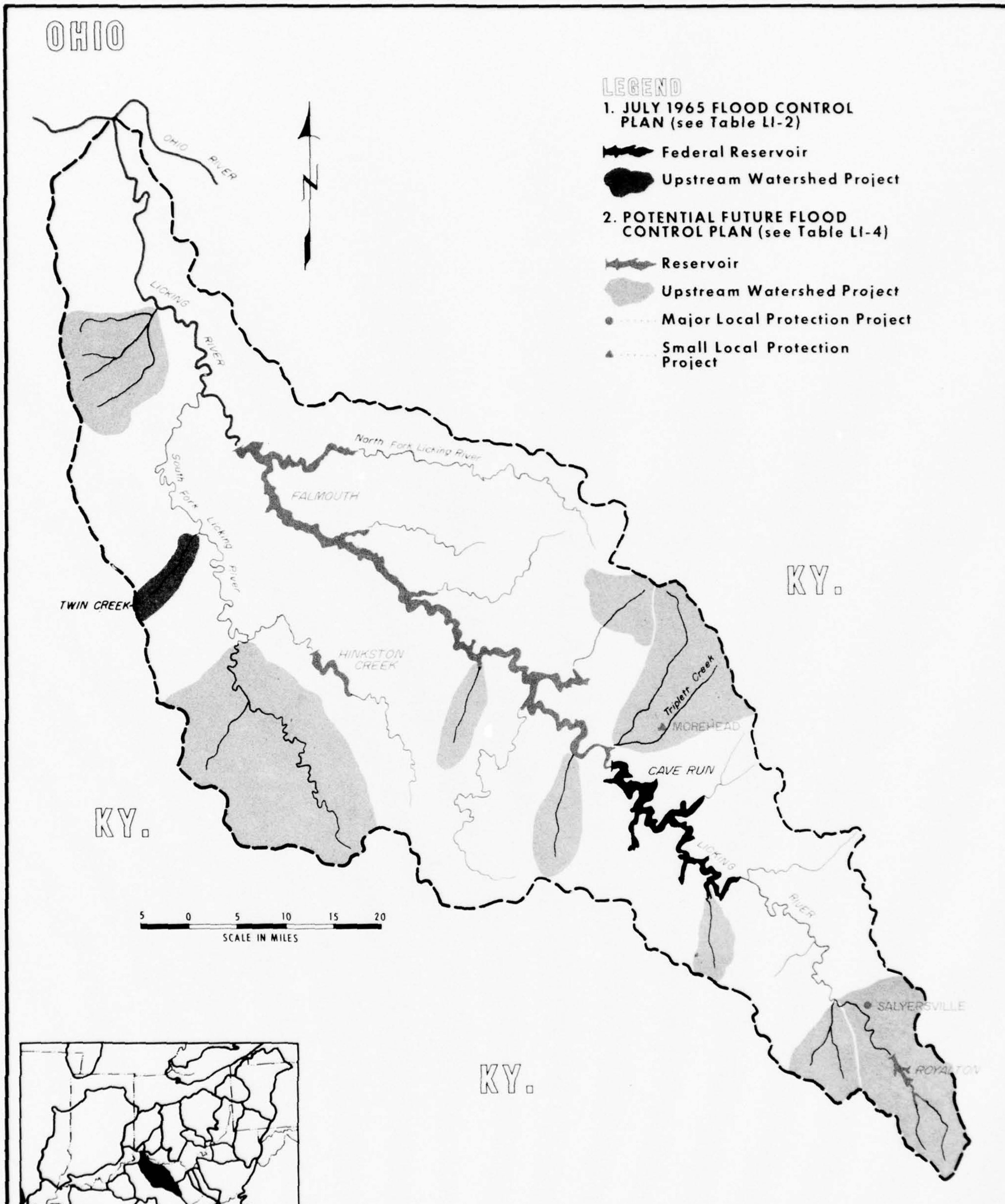
(1) July 1965 Status

A - Authorized project - Active status

D - Authorized project - Deferred status

P - Potential project

(2) Net below Cave Run Reservoir



OHIO RIVER BASIN COMPREHENSIVE SURVEY

LICKING RIVER BASIN FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE LI-1

14. Kentucky River Basin

The Kentucky River Basin lies entirely within the Commonwealth of Kentucky, and comprises all or considerable portions of 33 counties. From the mouth of the Kentucky River at Carrollton the basin extends southeasterly about 175 miles. Width of the basin varies from about 30 miles in the lower portion to 50 miles in the upper areas. The total drainage area is about 6,970 square miles of which 2,631 square miles are drained by three principal headwater tributaries, the North, Middle, and South Forks of the Kentucky River.

The Kentucky River is formed by the junction of its North and South Forks at Beattyville. Middle Fork enters North Fork about four miles upstream. From its point of beginning, the Kentucky River flows northwesterly about 255 miles to its junction with the Ohio River at about Mile 546 above the mouth. Average annual runoff for the basin is about 17 inches. The mean annual precipitation for the basin is about 45 inches with a maximum annual of about 67 inches and a minimum annual of 16 inches. Snow rarely remains on the ground for more than a few days at time and, in general, snowfall is a small contributing factor to floods.

Numerous major floods have occurred in the basin; however, the June 1957 flood was generally the most widespread. A recurrence of a composite of record floods without the intervening development of control works would result in $29.0 million in downstream damages and inundate almost 83,000 acres. The modified 100-year flood would be larger than the composite both in damages and area covered. (Table KE-1).

The July 1965 Federal flood control plan in the basin consists of five reservoirs, one upstream watershed project, and two major and three small local protection projects. (Table KE-2 and Figure KE-1). In downstream areas these projects will reduce average annual damages from $3.9 to $1.3 million, and in upstream areas, the upstream watershed project on Stillwater Creek has reduced annual damages by $8,000 annually. (Table KE-1). The flood control cost of this upstream watershed project is $165,000 and it consists of 6.4 miles of channel improvement and will protect 336 acres of flood plain.

The major urban flood problem area is on the North Fork of the Kentucky River in the vicinity of Hazard. In addition, future anticipated developments in unprotected areas around Frankfort and along the lower Kentucky River will present problems. Also, a flood problem of somewhat lesser magnitude exists at Manchester.

The Hazard area suffers severe flood damage during extensive floods, when a large portion of the residential and virtually all commercial enterprises are inundated. Encroachments on the natural stream channel and the flashiness of the stream aggravate the flood problem. The Carr Fork Reservoir will alleviate some of the problem at Hazard; however, a flood problem will still remain. Due to the restrictive flood plain areas, local protection works are not practical or feasible. A potential solution to the problem seems to be a reservoir located on the main stem or several on tributaries.

Unless flood plain management measures are implemented at Frankfort, the capital of Kentucky on the Kentucky River, additional protection works will eventually be required either by local measures or reservoirs upstream. Manchester, the remaining flood problem area, is located on both banks of Goose Creek, a tributary of the South Fork of the Kentucky River. Manchester and vicinity are subject to flooding and the greatest damage occurs to business and commercial properties upstream from the city limits. Presently a study is underway for a small channel improvement project at Manchester.

In downstream areas average annual damages of $1.3 million have been projected to increase to $4.7 million by 2020. (Table KE-3). In order to reduce projected downstream damages, 11 reservoirs and one small local protection project have been included in the potential future plan for downstream areas. (Table KE-4 and Figure KE-1).

Average annual damages of $750,000 in upstream areas have been projected to increase to $1.4 million by 2020. Structural measures supplementing land treatment have been found to be potentially feasible in 22 additional upstream watersheds. (Table KE-4 and Figure KE-1). They would contain 62 miles of channel improvement and 90 retarding structures, which could provide storages of 263,112 acre-feet for floodwater detention and 33,000 for sediment. These would cover an area of 2,160 square miles and their structures control 1,257 square miles. The average annual flood damages are estimated at $603,700 and they are assigned about equally to agricultural and urban developments. The damage per square mile of their watershed area is estimated at $279. The projects would reduce average annual damages in upstream areas by $482,000. They would protect more than 33,300 acres of flood plain and their improvements would provide an opportunity for enhancing land values through an estimated annual $310,000 increase in productivity.

Table KE-1

FLOOD PLAIN DATA - KENTUCKY RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Composite Historical Flood(2) Area Inundated (Acres)	Composite Historical Flood(2) Damages ($1,000)
Agricultural Crop	639	219		641		365
Agricultural Non-Crop	520	167		2,900		2,054
Residential	1,102	384		10,985		8,197
Commercial	976	330		12,192		9,647
Industrial	78	25		3,985		3,249
Other(3)	558	183		8,251		5,500
TOTAL	3,873	1,308	110,190	38,954	82,660	29,012

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)
Crop and Pasture	410	404
Other Agriculture	46	45
Transportation Facilities	57	56
Urban	167	167
Sediment and Erosion	10	10
Indirect(4)	68	68
TOTAL	758	750

Category	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)
Crop		1,288
Non-Crop		145
Residential		313
Commercial and Industrial		218
Other(3)		212
TOTAL	42,570	2,176

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: January-February 1937, February 1939, June 1947, June 1957, March 1962, March 1963.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table KE-2

JULY 1965 FLOOD CONTROL PLAN

KENTUCKY RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65 [1] Status	Purpose [2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Buckhorn	C	F,R	408	168.0	10.3	0.5	157.7w [3]	7.2	136.0s [3]
Carr Fork	UC	F,Q,R	58	47.7	11.8	3.8	31.7w	10.2	25.2s
Eagle Creek	AP	F,M,Q,R	292	267.5	15.4	1.0	197.0w	12.6	100.5s
Red River	AP	F,M,Q,R	219	186.0	12.0	1.1	120.0w	10.3	109.0s
Booneville	AP	F,R	686	473.0	37.7	0.9	404.0w	11.2	365.0s

B. UPSTREAM WATERSHED PROJECTS

Subbasin and Watershed Project	Purpose [4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Red River, Ky	FP	24.0	-	-	-	-	-	-	6.0

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 [1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Jackson, Ky, North Fork Kentucky River	C	-	-	-	Channel cutoff
Frankfort, Ky, Kentucky River (North Area)	UC	0.4	0.3	-	

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 [1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Neon Fleming, Ky, Boone, Wright & Yonts Forks	C	-	-	2.0
Snagging & Clearing Projects				
Hindman, Ky, Troublesome Creek	AP			
Whitesburg, Ky, North Fork Kentucky River	AP			

II. NON-FEDERAL

NONE

NOTES: (1) July 1965 Status C - Completed UC - Under construction AP - Authorized - Advanced planning

(2) Purpose: F - Flood control Q - Water quality M - Water supply R - Recreation

(3) w - Winter
s - Summer

(4) Purpose: FP - Flood prevention

Table KE-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

KENTUCKY RIVER BASIN

	Average Annual Damages ($1,000)			
	Residual	Projected		
Area Location	1965	1980	2000	2020
Downstream	1,308	1,890	2,980	4,730
Upstream	750	920	1,171	1,443
Total Basin	**2,058**	**2,810**	**4,151**	**6,173**

Table KE-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

KENTUCKY RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65 (1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Kingdom Come	P	131	49.0	73.0
Walkers Creek	P	1,260	147.0	180.5
Station Camp Creek	P	95	30.0	290.0
Ford	P	2,503	510.0	840.0
Troublesome Creek	P	201	71.2	112.0
Red Bird River	P	115	55.0	90.0
Little Goose Creek	P	38	20.4	30.0
Cutskin Creek	P	84	49.0	69.0
Greasy Creek	P	51	16.1	30.2
Line Fork	P	64	58.6	62.0
Leatherwood Creek	P	49	32.4	35.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
22	2,160	90	1,257	438,412	12,393	62

C. MAJOR LOCAL PROTECTION PROJECTS

None defined at present

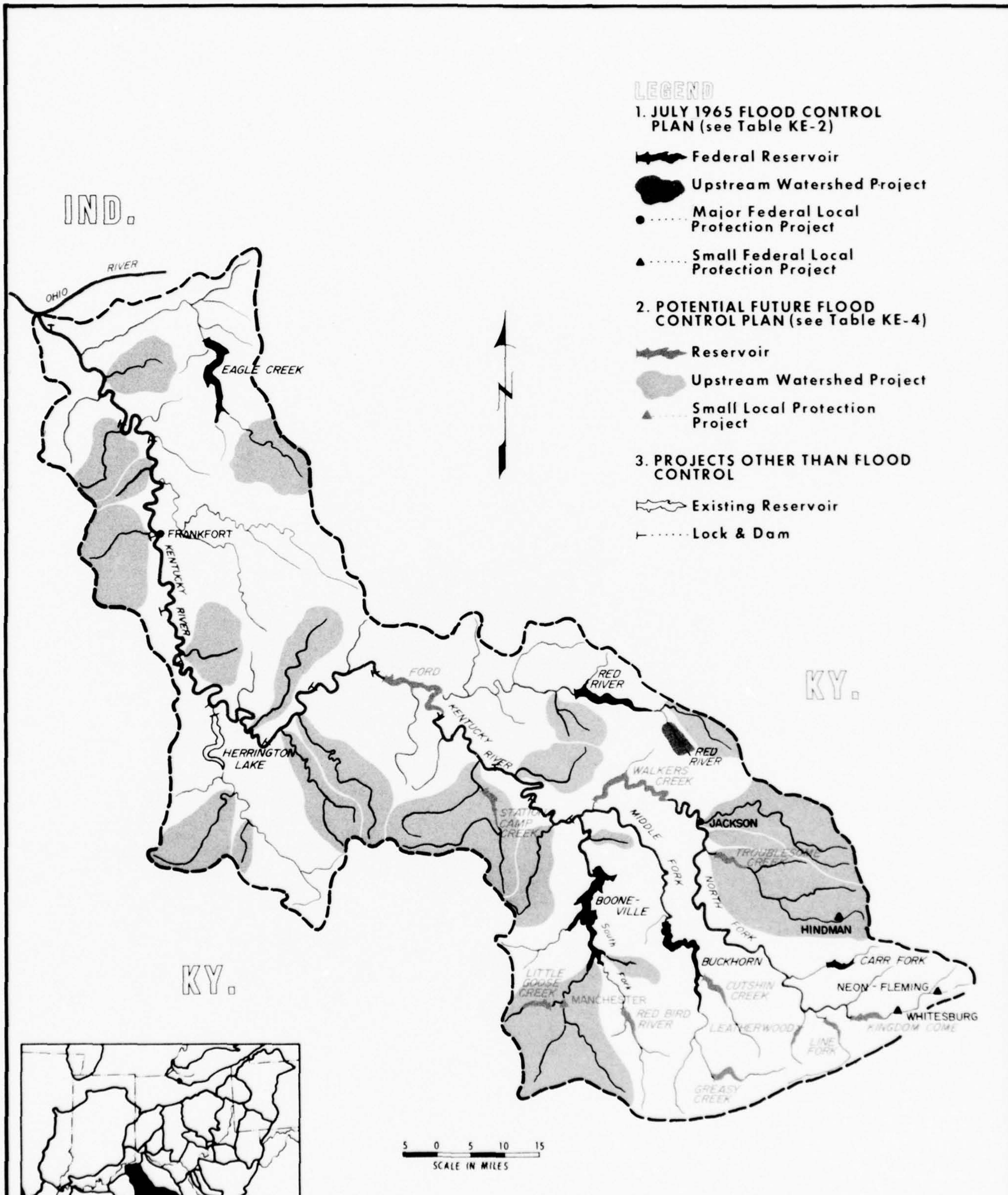
D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Remarks
Manchester, Ky, Goose Creek	P	Channel improvement

NOTE:

(1) July 1965 Status

P - Potential



OHIO RIVER BASIN COMPREHENSIVE SURVEY

KENTUCKY RIVER BASIN
FLOOD CONTROL PROJECT
DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE KE-1

15. Salt River Basin

The Salt River Basin lies wholly within the Commonwealth of Kentucky and comprises an area of about 2,890 square miles. The Salt River rises in Boyle County just west of the town of Danville. It flows northward for about 50 miles to the vicinity of Lawrenceburg and thence west about 100 miles to its confluence with the Ohio River at West Point, 26 miles below Louisville and 351 miles above the mouth of the Ohio River. Along the main stem and the Rolling Fork tributary, the flood plain varies in width from a quarter mile to about four miles. The flood plain along the other tributaries varies in width from about 300 to 2,000 feet. The mean annual precipitation for the basin is about 46 inches, while the average annual runoff is about 17 inches.

Flooding along the Salt River occurs almost every year, and often several times in a year. The maximum headwater flood along Salt River and most of its tributaries was the occurrence of March 1964. Other major headwater floods occurred in January 1937, March 1939, March 1945, February 1948, and May 1961. The maximum stage attained in the downstream reaches was in January 1937 as a result of Ohio River backwater. These floods caused extensive tangible damages, delayed transportation movements, and disrupted economic activity of the basin. A recurrence of the May 1961 flood would cause about $3.8 million in damages, and inundate 52,080 acres in downstream areas. However, a modified 100-year flood would result in damages almost three times as great. (Table SA-1).

The July 1965 Federal flood control plan in the basin consists of one major and three small local protection projects and one upstream watershed project. (Table SA-2 and Figure SA-1). The completed Plum Creek watershed project, Spencer and Shelby Counties, is the only authorized one for the basin. Its improvements consist of 12 retarding structures and 21 miles of channel improvement. It covers an area of 37 square miles, of which runoff from 11 are controlled by structures. The flood control measures have cost $342,700 and they will prevent $42,000 in annual damages.

There are no major urban flood damage centers in the basin. The residual losses are about 70 percent agricultural in nature with minor flood problem areas located at Shephердsville, Lebanon Junction, and Harrodsburg. The agricultural lands susceptible to flood damages are located along the lower Salt River and its largest tributary, Rolling Fork. These areas, with the exception of Harrodsburg, suffer from both headwater floods and backwater from the Ohio River.

The potential Taylorsville Reservoir would reduce some of the agricultural flood damage. A major local protection project would alleviate the problem at Shepherdsville while small flood control projects would eliminate problems at Lebanon Junction and Harrodsburg. In downstream areas present average annual damages of $2.1 million have been projected to increase to $5.9 million by 2020. (Table SA-3). The potential future flood control plan for downstream areas consists of four reservoirs and one major and two small local protection projects. (Table SA-4 and Figure SA-1).

Annual damages of $242,000 in upstream areas are expected to increase to about $383,000 by 2020 without further project development. (Table SA-3). There are ten potentially feasible upstream watershed projects consisting of six miles of channel improvement and 46 retarding structures, which could provide storages of 94,600 acre-feet for floodwater detention and 12,000 for sediment. (Table SA-4 and Figure SA-1). The structures would control runoff from 449 square miles or 53 percent of the area. The average annual flood damages are estimated at $229,000, mainly to agricultural crops. The damage per square mile of their watershed area is estimated at $270. These potentially feasible projects would reduce average annual damage in upstream areas by $183,000. They would protect more than 13,400 acres of flood plain and their improvements would provide an opportunity for enhancing land values through an estimated annual $142,000 increase in productivity.

At present, a basinwide survey is underway. It will define the short and long-term needs in detail for downstream flood control and other water resource functions and recommend appropriate solutions. Preliminary indications are that additional flood control reservoirs are required as well as storage for water supply and water quality purposes. A recently completed interim report recommended a multiple-purpose reservoir near Taylorsville.

Table SA-1

FLOOD PLAIN DATA - SALT RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Historical Flood(2) Area Inundated (Acres)	Historical Flood(2) Damages ($1,000)
Agricultural Crop	504	496		1,109		601
Agricultural Non-Crop	806	800		875		889
Residential	758	565		4,944		1,674
Commercial	243	89		2,253		337
Industrial	Minor	Minor		366		4
Other(3)	186	138		1,071		335
TOTAL	2,497	2,088	77,290	10,618	52,080	3,840

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)
Crop and Pasture	191	176
Other Agriculture	38	18
Transportation Facilities	5	4
Urban	20	20
Sediment and Erosion	9	3
Indirect(4)	21	21
TOTAL	284	242

Category	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)
Crop		563
Non-Crop		58
Residential		35
Commercial and Industrial		23
Other(3)		23
TOTAL	15,420	702

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) May 1961 flood.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table SA-2

JULY 1965 FLOOD CONTROL PLAN

SALT RIVER BASIN

I. FEDERAL

A. RESERVOIRS

None

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose(2)	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Plum Creek, Ky	FP	37.0	12	11.0	304	2,163	-	2,467	21.0

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65(1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Taylorsville, Ky, Salt River	C	8.1	-	-

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65(1) Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Harrodsburg, Ky, Town Creek	AP	-	-	1.0

Snagging & Clearing Projects

Plum Creek, Ky	C
Salt River below Shepherdsville, Ky	C

II. NON-FEDERAL

None

NOTES: (1) July 1965 Status: C - Completed AP - Authorized - Advanced planning UC - Under construction

(2) Purpose: FP - Flood prevention

Table SA-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

SALT RIVER BASIN

Area Location	Average Annual Damages ($1,000): Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	2,088	3,043	4,151	5,905
Upstream	242	281	334	383
Total Basin	2,330	3,324	4,485	6,288

Table SA-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

SALT RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65(1) Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Camp Ground	P	438	344.0	448.6
Howardstown	P	384	307.0	369.3
Floyds Fork	P	42	70.0	139.5
Taylorsville	P	354	278.8	399.1

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Total Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
10	848	46	449	197,613	8,616	6

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65(1) Status	Type of Project and Length in Miles		
		Earth Levee	Concrete Flood Wall	Channel
Shepherdsville, Ky Salt River(2)	P			

D. SMALL LOCAL PROTECTION PROJECTS

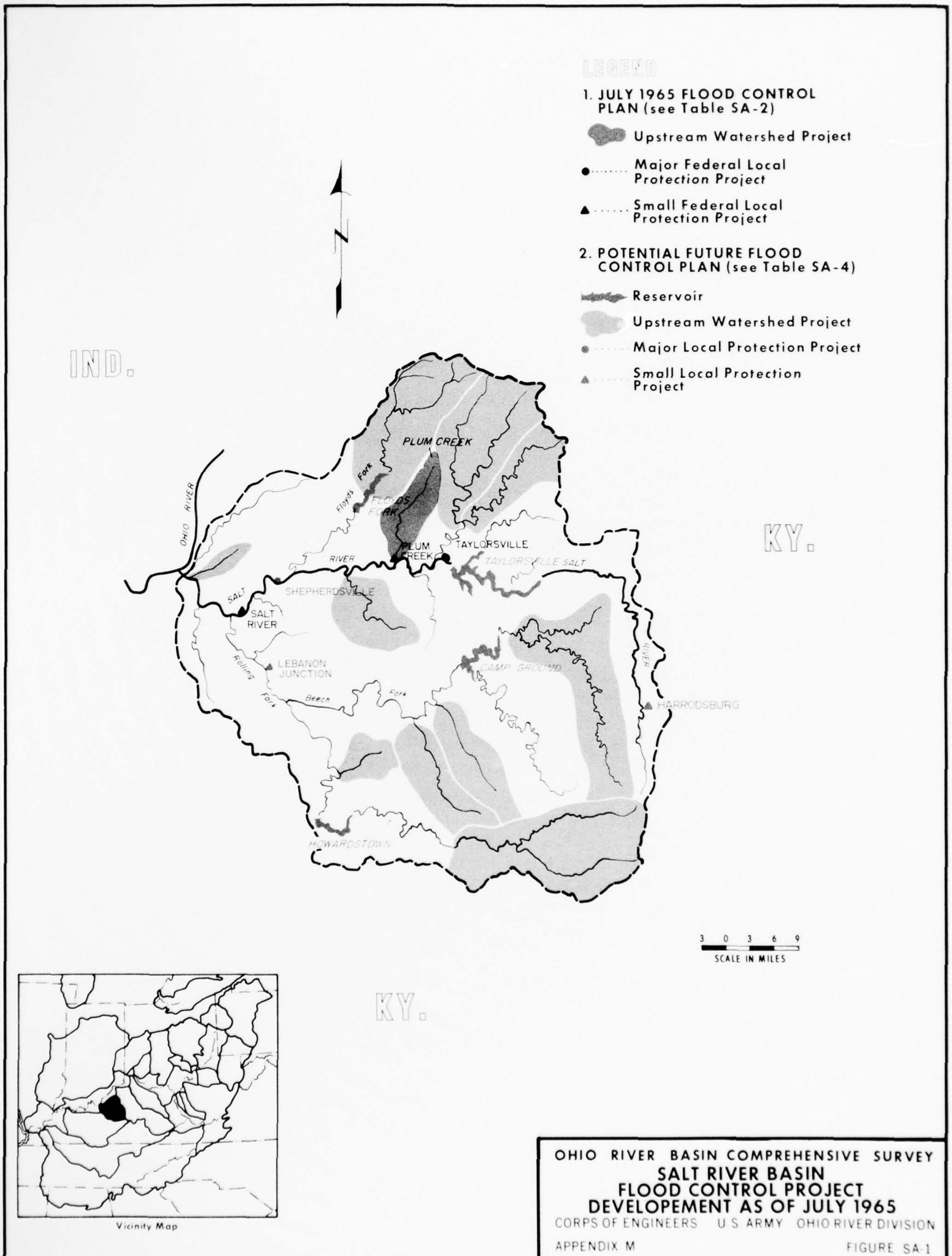
Project Location	Jul 65(1) *Status*	*Remarks*
Lebanon Junction, Ky, Rolling Fork River	P	Earth Levee
Harrodsburg, Ky, Town Creek	P	Channel improvement

NOTES:

(1) July 1965 Status

P - Potential project

(2) Project dimensions not defined at this time



OHIO RIVER BASIN COMPREHENSIVE SURVEY

SALT RIVER BASIN FLOOD CONTROL PROJECT DEVELOPEMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE SA-1

16. Green River Basin

The Green River rises in Lincoln County, Kentucky and has a total length of about 370 miles. It flows in a general westerly direction for more than one half of its total length, to Butler County, Kentucky, thence in a northwesterly direction to its confluence with the Ohio River about eight miles above Evansville, Indiana. The shape of the basin is roughly rectangular, with a width-length ratio of approximately 0.6. The drainage area is approximately 9,230 square miles, comprising all or part of 28 counties in west-central Kentucky, and a small part of three counties in north-central Tennessee. The topography of the basin is generally uneven, with occasional hills 300 to 400 feet high and river valleys 100 to 200 feet deep. The highest elevation within the basin, approximately 1,800 feet above mean sea level, is in Lincoln and Casey Counties, Kentucky. The Green River valley above Greensburg, Kentucky, is relatively narrow and has a depth between the flood plain and the adjacent uplands of over 200 feet. Progressing upstream from this area, the valley widens and the depth of stream intrenchment becomes somewhat less.

Flooding in the Green River Basin occurs every year and often several times a year. For example, eleven damaging floods have occurred on Green River at the Woodbury, Kentucky, gaging station during the period 1955 to 1962. Medium and high stage floods usually occur in the winter and spring months inundating vast areas of tillable lands and remain above flood stage for prolonged periods. The maximum flood of record in the Green River Basin occurred in January-February 1937. This flood inundated essentially all of the flood plain and remained above flood stage at Woodbury for twenty-five days. Other floods that are considered to be in the major flood category occurred in March 1913, March 1945, March 1952, and March 1962. A recurrence of a composite of the major record floods would cause $10.8 million in downstream damages and inundate more than 421,000 acres of flood plain if it were not for the intervening control works. Its damage would exceed that of the modified 100-year flood and it would cover a greater area. (Table GR-1).

The July 1965 Federal flood control plan in the basin consists of four reservoirs, one major and two small local protection projects, and 12 upstream watershed projects. (Table GR-2 and Figure GR-1). Operation of the four reservoirs in the basin will reduce the basin's natural annual damages by over 50 percent and control streamflow from 30 percent of the drainage area. The basin's 12 authorized watershed projects encompass an area of 1,293 square miles with the runoff from approximately 509 controlled by 89 retarding structures. These structures will have storages of 12,800 acre-feet for sediment and 73,600 for flood water detention. The cost of their flood control measures will amount to approximately $13 million and they will prevent $346,000 in annual damages on 52,000 acres of flood plain.

There are no major urban damage centers in the basin. Principal damages experienced are to agricultural properties and transportation routes. Damages to the agricultural properties are to lands, developments and field crops. Significant among the non-crop damages are erosion of top soil, deposition of sands and gravels, and the spreading of seeds of

noxious weeds. During medium and high stage floods, damages to fences, outbuildings and homesteads are extensive. Many acres of land and groups of outbuildings have been abandoned because of the frequency of this extensive damage. Flooding at almost anytime of the year results in some crop loss. Spring floods are particularly damaging, because of delays in planting and expensive replanting costs. Often, because of prolonged duration, many areas are isolated and inaccessible for long periods resulting in a short growing season. The numerous transportation routes experience considerable damage to fills, surfacing and structures. The deposition of soils in the many drainage ditches and culverts necessitates extensive cleaning and is particularly costly. The number of roads affected by flooding results in long delays in travel and expensive detours.

In downstream areas average annual damages of $2.0 million are projected to increase to $3.7 million by 2020. (Table GR-3). The potential future downstream flood plan consists of one reservoir and two small local protection projects. (Table GR-4 and Figure GR-1). In upstream areas, average annual damages of $2.2 million are expected to increase to $3.8 million by 2020. (Table GR-3). Structural measures supplementing land treatment have been found to be potentially feasible in 45 additional upstream watersheds. They would contain about 300 miles of channel improvement and 192 retarding structures which could provide storages of 201,000 acre-feet for floodwater detention and 35,000 for sediment. (Table GR-4 and Figure GR-1). These would cover 3,431 square miles with 1,311 controlled by the structures. The average annual flood damages are estimated at $1.8 million, mainly to crops and agricultural improvements. The damage per square mile of their watershed area is estimated at $529. The potentially feasible projects would reduce average annual damages in upstream areas by $1.5 million. They would protect about 167,300 acres of flood plain, and improvements would provide an opportunity for enhancing land values through an estimated annual $1.7 million increase in productivity.

Table GR-1

FLOOD PLAIN DATA - GREEN RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Composite Historical Flood(2) Area Inundated (Acres)	Composite Historical Flood(2) Damages ($1,000)
Agricultural Crop	2,056	1,101		2,687		4,836
Agricultural Non-Crop	1,379	559		2,392		2,021
Residential	194	69		771		1,134
Commercial	95	34		349		469
Industrial	86	30		353		428
Other(3)	685	236		1,443		1,976
TOTAL	4,495	2,029	405,790	7,995	421,290	10,864

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Category	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)
Crop and Pasture	1,752	1,555	Crop		5,133
Other Agriculture	220	188	Non-Crop		621
Transportation Facilities	135	98	Residential		177
Urban	133	94	Commercial and Industrial		147
Sediment and Erosion	50	41	Other(3)		459
Indirect(4)	235	203			
TOTAL	2,525	2,179	TOTAL	220,220	6,537

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: January 1913, January-February 1937.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table GR-2

JULY 1965 FLOOD CONTROL PLAN

GREEN RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage		Flood Control Storage		
							Major Flood Season		Conservation Season
					1,000 Ac Ft	Inches	1,000 Ac Ft	Inches	1,000 Ac Ft
Rough River	C	F,R	454	334.4	20.2	0.8	314.2w[3]	13.0	214.4s[3]
Barren River	C	F,M,R	940	815.2	45.9	0.9	768.6w	15.3	558.8s
Nolin River	C	F,Q,M,R	703	609.4	39.3	1.0	408.5w	10.8	277.6s
Green River	UC	F,Q,M,R	682	723.2	98.1	2.7	560.6w	15.4	479.1s

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose[4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage				Channel Improvements (Miles)
					Sediment (Ac Ft)	Floodwater (Ac Ft)	Other Uses (Ac Ft)	Total (Ac Ft)	
Beaver Creek, Ky	FP	52.9	1	33.5	529	3,749		4,278	
Big Muddy Creek, Ky	FP	101.8	5	39.5	1,255	5,924		7,179	17.5
Big Reddy Creek, Ky	FP	41.2	2	11.1	199	1,425		1,624	9.3
Caney Creek, Ky	FP,R,M&I	152.0	10	68.2	2,217	10,075	258	12,550	20.0
East Fork Pond River, Ky	FP	218.2	17	115.3	2,559	13,794		16,353	53.4
Line Creek, Tenn & Ky	FP	63.0	5	30.8	678	8,215		8,895	38.0
Mud River, Ky	FP,R,M&I	375.0	26	131.8	2,910	17,795	16,137	36,842	15.6
Short Creek, Ky	FP	38.0	3	14.3	351	2,268		2,619	4.5
Upper Green River, Ky	FP	38.0	5	3.7	76	646		722	12.0
Upper North Fork Rough River, Ky	FP	40.0	2	5.5	94	1,028		1,122	10.0
Valley Creek, Ky	FP,M&I,R	90.6	4	20.4	769	3,750	1,600	6,119	
West Fork Pond River, Ky	FP,M&I	82.7	9	35.2	1,218	4,923	80	6,221	25.0

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles		
		Earth Levee	Concrete Flood Wall	Channel
Rough River Channels	C	-	-	64

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status
Snagging & Clearing Projects	
Cypress Creek, Ky	C
Rough River at Falls, Ky	C

II. NON-FEDERAL

None

NOTES: (1) July 1965 Status: C - Completed UC - Under construction

(2) Purpose: F - Flood control M - Water supply R - Recreation Q - Water quality

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention R - Recreation M&I - Municipal and industrial water supply

Table GR-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

GREEN RIVER BASIN

Area Location	Average Annual Damages ($1,000) Residual 1965	Projected 1980	Projected 2000	Projected 2020
Downstream	2,029	2,348	2,851	3,679
Upstream	2,179	2,478	3,062	3,844
Total Basin	4,208	4,826	5,913	7,523

Table GR-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

GREEN RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Drakes Creek	P	500	270.0	307.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
45	3,431	192	1,311	804,963	35,202	296

C. MAJOR LOCAL PROTECTION PROJECTS

None defined at this time

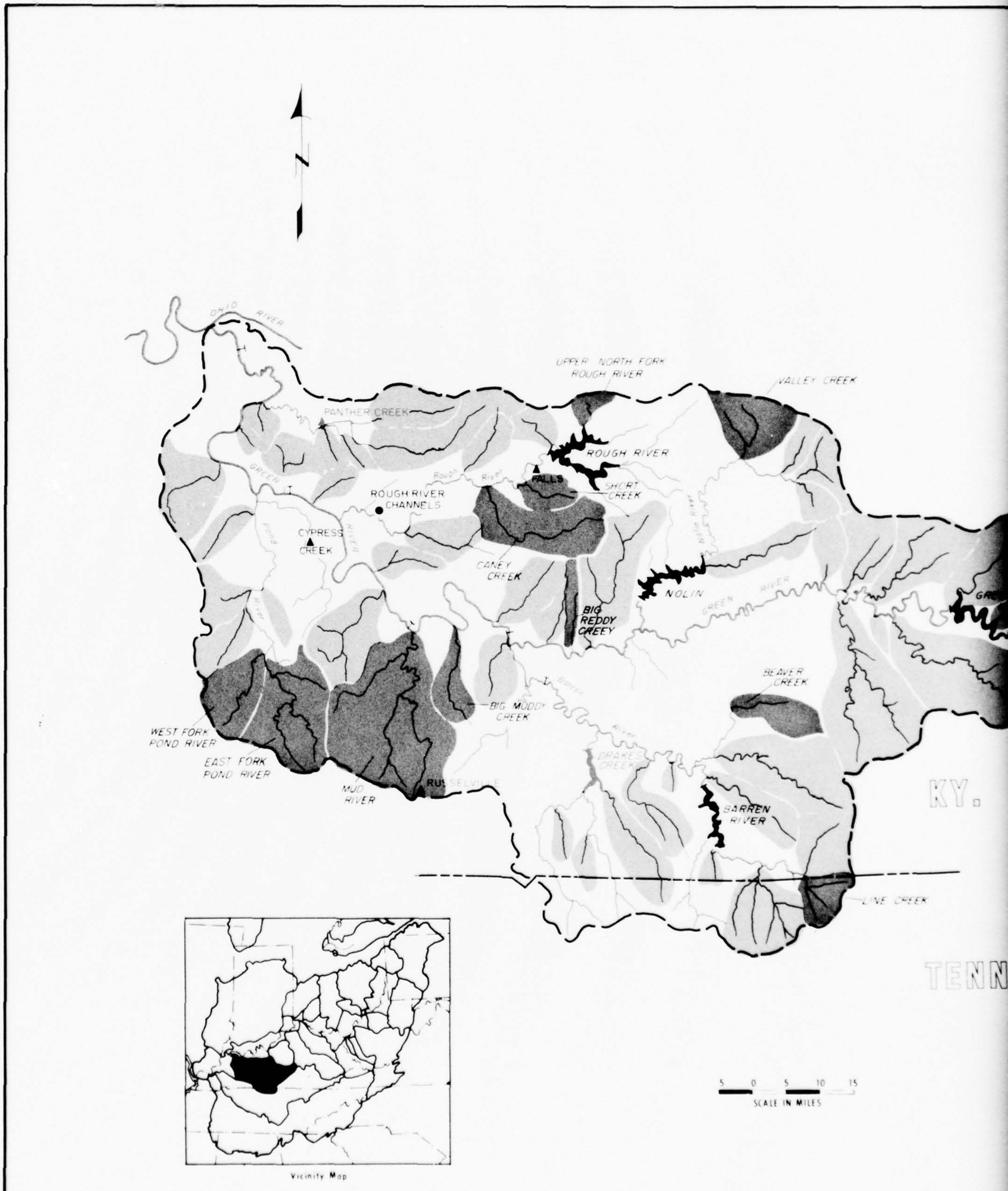
D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Remarks
Panther Creek, Ky	P	Channel improvement
Russellville, Ky, Town Branch	P	Channel improvement

NOTE:

(1) July 1965 Status

P - Potential project



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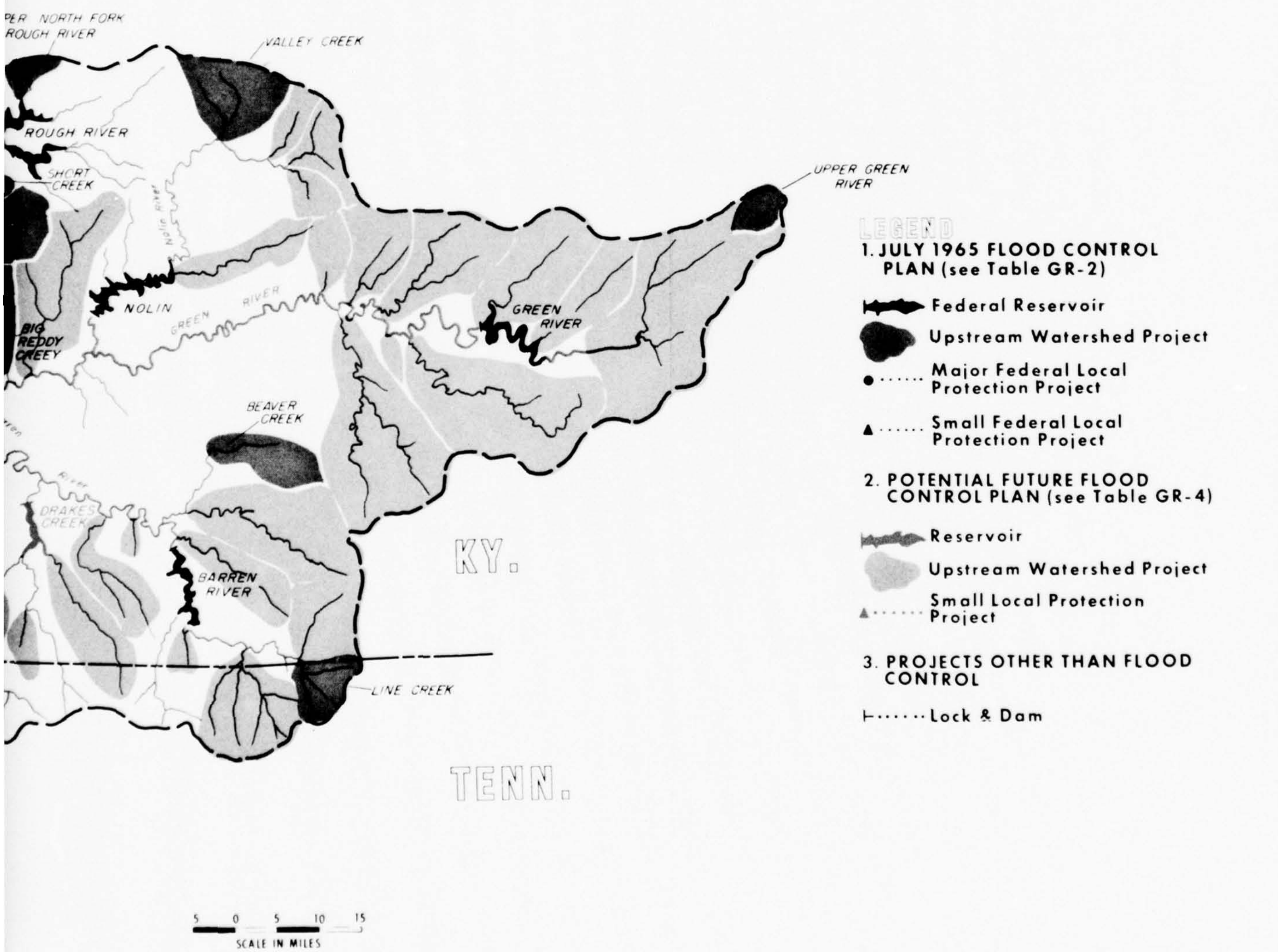


OHIO RIVER BASIN COMPREHENSIVE SURVEY

GREEN RIVER BASIN
FLOOD CONTROL PROJECT
DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE GR 1

17. Wabash River Basin

The Wabash River Basin is an approximately oval drainage area of 33,100 square miles, 319 lying in western Ohio, 8,563 in eastern Illinois, and 24,218 in Indiana. The length of the basin is about 285 miles, and its maximum width about 190 miles. The Wabash River rises near Celina, Ohio, flows northwesterly 67 miles to Huntington, Indiana, thence generally west and southwest 312 miles to the confluence of the White River, its major tributary. It then continues southwesterly 96 miles to join the Ohio River, at a point 133 miles above its junction with the Mississippi River, for an overall length of about 475 miles. The mean annual precipitation for the basin is about 40 inches. Snow rarely remains on the ground for more than a few days at a time, and in general, snowfall is a small contributing factor to floods. The average annual snowfall for the area is about 20 inches (unmelted). Average annual runoff for the basin is about 12 inches.

Floods in the Wabash Basin have occurred in every month of the year, but those of summer and fall ordinarily have less areal coverage than those of winter and spring. Since the August 1875 high water, all major floods have occurred in the winter and spring months. The March 1913 flood was the most devastating runoff period in the history of the Wabash River Basin. Since 1913 the five floods of greatest magnitude, from the standpoint of areal coverage, are May 1943, January-February 1950, May 1933, March 1939, and January 1930. A composite of record floods without the intervening development of control works would cause about $94.8 million in downstream damages and flood more than 1.4 million acres. The damage from a composite flood is about 50 percent greater than that expected from the modified 100-year flood, and it would inundate a slightly greater area. (Table WA-1).

The July 1965 Federal flood control plan consists of 6 reservoirs, 17 major and four small local protection projects and 16 upstream watershed projects. In addition there are numerous improvements by local entities. (Table WA-2 and Figure WA-1). The six reservoirs in the plan are Mansfield, Mississinewa, Salamonie, Huntington, Cagles Mill and Monroe. These reservoirs will control 3,016 square miles of drainage area and will provide 1,321,000 acre-feet of flood control storage. These reservoirs in conjunction with the local protection projects will reduce average annual damages from $38.8 million to $20.3 million in the downstream areas of the basin. (Table WA-1).

The basin's 16 authorized watershed projects will provide protection to 1,253 square miles. They consist of 306 miles of channel improvement and 78 retarding structures which control 350 square miles and have storages of 55,072 acre-feet for floodwater detention and 8,180 for sediment. Their flood prevention cost is $14.9 million. Average annual damages will be reduced to $242,000 on 48,300 acres of flood plain.

Fertile farm lands comprise the flat, broad flood plains of the Wabash and White Rivers. They are susceptible to extensive and recurrent flooding generally along their entire length. Heavy agricultural damages

Photo 21. Flooding of agricultural lands in the Wabash River Basin.

are incurred because of the flat topography and sluggish streams. It is of particular significance that many agricultural levees are overtopped or breached during major flooding at a time when repairs prior to the growing season are virtually impossible. Medium and low stage floods have happened during every month of the year but are of particular importance when occurrences have been in the late spring or early summer months. Flooding during this period delays planting, necessitates costly replanting, and sometimes prevents the use of arable lands for an entire cropping season. In the lower portion of the Wabash River where the overflow area is largely unprotected, major tributaries contribute considerable inflow, which when combined with Ohio River backwater often maintains stages above bankfull for periods up to 50 days. Soil conditions after such flooding are such that preparation and planting cannot be accomplished during that crop season.

Numerous urban areas have flood problems; however, the major urban damage centers in the basin are located at Indianapolis, Columbus and Marion, Indiana. Subsequent to the 1913 flood in the Wabash River Basin, local interests developed and undertook a comprehensive plan of improvement to protect the City of Indianapolis against a flood similar to that of 1913. The plan included channel improvement, reconstruction or alteration of existing bridges, and construction of levees, walls and appurtenant works. Local interests had accomplished a considerable portion of the plan by the time the Federal project was authorized. The Flood Control Act, approved June 22, 1936, authorized Federal participation in accomplishing

two integral parts of the city's comprehensive plan which are identified as the Fall Creek and Warfleigh Sections. The Federal project included channel improvement with attendant earth levees and concrete walls and reconstruction or alteration of bridges as required for the improved channel. The portion of the Fall Creek Section extending from Washington Street upstream to 10th Street has been completed.

A project of comprehensive scope affording a high degree of protection will be provided when the city's entire plan is completed. Further progress toward this end has been made by the city, which undertook much additional flood control construction utilizing, where available, planning work previously accomplished by the Corps of Engineers. Unaccomplished portions of the Federal project have been considered inactive for several years, but recently local interests have indicated a renewal of interest in Federal participation. Currently an economic study of the Warfleigh section is being made. It is estimated that the completed work has prevented flood damages amounting to $2,210,000 at Indianapolis during the period 1943 to date.

Columbus, the seat of Bartholomew County, is located where Flatrock River joins Driftwood River to form East Fork White River. Development in the area subject to flooding consists of all categories of property associated with urbanized areas. The Big Blue and Downeyville Reservoirs in the potential future flood control plan would provide a reduction in annual flood losses.

Marion, the seat of Grant County, lies in the northeast portion of Indiana approximately 60 miles northeast of Indianapolis. The city is located on both banks of the Mississinewa River and extends from river Mile 35 to Mile 41 above the mouth of the stream. Total area of the city is about 7,300 acres of which about seven percent or an area of about 500 acres is in the flood plain. Areas subject to inundation are affected only by extreme floods. In recent studies in connection with the Wabash Comprehensive Survey, it was concluded that a local protection project consisting of a system of floodwalls and levees was the best method of protecting the Marion flood plain area.

In downstream areas average annual damages of $20.3 million have been projected to increase to $34.8 million by 2020. (Table WA-3). The potential future flood control plan for downstream areas consists of 29 reservoirs, and 36 major and four small local protection projects. (Table WA-4 and Figure WA-1).

Without further project development, annual damages of $16.1 million in upstream areas is expected to increase to $37.2 million by 2020. (Table WA-4). There are 198 potentially feasible watershed projects in the upstream areas. (Table WA-4 and Figure WA-1). They would contain about 16,628 square miles, or 49 percent of the basin drainage area. In these projects, 1,701 miles of channel improvement and 591 retarding structures would protect 679,726 acres of upstream flood plain. The structures would control 27 percent of the watersheds and could provide storages of 961,815 acre-feet for floodwater detention and 118,980 for sediment. The average

annual flood damages are estimated at $12.3 million, with about 98 percent attributed to agricultural developments. The damage per square mile of their watershed area is estimated at $739. The projects would reduce average annual damages in upstream areas by $9.8 million. They would provide an opportunity for enhancing land values through an estimated annual $3.8 million increase in productivity.

Residual flood damages will be significant in most areas of the basin even after construction of projects presently authorized and proposed. The continuing studies for the Wabash Comprehensive Report, a comprehensive survey for the optimum development of the basin's water and related land resources, are scheduled to investigate additional reservoir sites and review levee justification in many locations throughout the basin.

Table WA-1

FLOOD PLAIN DATA - WABASH RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

	Average Annual Damages ($1,000)		100 Year Modified Flood(1)		Composite Historical Flood(2)	
Category	Natural	Modified(1)	Area Inundated (Acres)	Damages ($1,000)	Area Inundated (Acres)	Damages ($1,000)
Agricultural Crop	17,677	11,732		10,011		9,627
Agricultural Non-Crop	8,610	5,463		20,021		21,093
Residential	5,816	950		16,609		31,901
Commercial	2,596	459		6,313		12,320
Industrial	633	203		2,595		6,145
Other(3)	3,438	1,510		11,005		13,770
TOTAL	38,770	20,317	1,504,800	66,554	1,432,200	94,856

B. UPSTREAM AREAS

	Average Annual Damages ($1,000)	
Category	Natural	Modified(4)
Crop and Pasture	13,834	13,656
Other Agriculture	483	472
Transportation Facilities	397	385
Urban	50	40
Sediment and Erosion	99	91
Indirect(5)	1,455	1,432
TOTAL	16,318	16,076

	100 Year Modified Flood(4)	
Category	Area Inundated (Acres)	Damages ($1,000)
Crop		42,781
Non-Crop		1,454
Residential		71
Commercial and Industrial		43
Other(3)		1,468
TOTAL	1,142,800	45,817

NOTES:
(1) Modified by Corps of Engineers projects completed, under construction, and in preconstruction planning as of July 1965.
(2) Floods used for composite: January 1913, May 1943, June 1957, January 1959, February 1961.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Modified by Soil Conservation Service flood control projects constructed, under construction, and those approved for operations as of July 1965.
(5) Indirect damages including interruption to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table WA-2

JULY 1965 FLOOD CONTROL PLAN

WABASH RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
Cagles Mill	C	F,R	295	228.1	27.1	1.7	201.0	11.1	201.0
Mansfield	C	F,R	216	132.8	16.2	1.4	116.6w[3]	10.1	83.5s[3]
Huntington	UC	F,R	702	153.1	4.1	0.1	149.0w	4.0	140.6s
Mississinewa	UC	F,R	809	368.4	23.3	0.5	345.1w	8.0	293.2s
Monroe	UC	F,M,Q,R	441	441.0	22.3	1.0	258.8	17.8	258.8
Salamonie	UC	F,R	553	263.6	13.1	0.4	250.5w	8.5	202.9s

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose[4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Upper Wabash, Ohio	FP	126.0	3	19.3	370	2,101	-	2,471	38.2
Busseron, Ind	FP,R,M&I	236.8	26	112.1	3,778	21,829	14,029	39,636	52.9
Stucker Fork, Ind	FP	184.0	16	67.9	1,091	10,980	-	12,071	25.6
Dewitt Creek, Ind	FP	14.1	2	6.2	168	695	-	863	2.3
Bachelor Run, Ind	FP	36.7	-	-	-	-	-	-	20.6
Kickapoo Creek, Ind	FP	38.6	-	-	-	-	-	-	9.3
Lattas Creek, Ind	FP	55.9	-	-	-	-	-	-	22.4
Little Wee Creek, Ind	FP	18.7	-	-	-	-	-	-	8.6
Prairie Creek-Vigo, Ind	FP	29.8	3	15.1	635	2,063	-	2,698	4.9
Prairie Creek-Daviess, Ind	FP,R	138.5	11	38.6	1,275	3,771	174	5,220	33.5
Elk Creek, Ind	FP,F&WL	28.2	8	7.3	39	841	494	1,374	10.8
French Lick, Ind	FP,F&WL	34.2	4	11.9	267	2,892	1,302	4,461	5.1
Boggs Creek, Ind	FP	63.7	2	49.2	141	4,658	-	4,799	8.2
Twin Rush, Ind	FP,M&I	43.9	3	22.2	416	5,242	3,020	8,768	9.9
Mill Creek-Fulton, Ind	FP	90.0	-	-	-	-	-	-	16.3
Scattering Fork, Ill	FP	114.1	-	-	-	-	-	-	37.6

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Brevoort Levee, Ind, Wabash & White Rivers	C	37.1	-	-	
Delphi, Ind, Wabash River	C	0.6	-	-	
Gill Twp Levee, Ind, Wabash River	C	12.9	-	-	
Indianapolis, Ind, White River	C	0.7	0.2	1.2	
Levee Unit #8 Ind, White River	C	17.6	-	-	
Lyford Levee, Ind, Wabash River	C	7.8	-	-	
Muncie, Ind, White River	C	4.5	0.9	3.8	
New Harmony Bridge, Ill, Wabash River	C	-	-	-	Dike & Cutoff Channel
Mason J. Niblack, Ind, Wabash River	UC	17.0	-	-	
Levee Unit #5, Ind, Wabash & Patoka Rivers	UC	41.9	-	-	
Mt. Carmel, Ill, Wabash River	UC	3.0	0.3	-	
Rochester - McClearys Bluff, Ill, Wabash River	UC	9.1	-	-	
Tri-Pond Levee, Ill, Wabash River	UC	8.4	-	-	
Vincennes, Ind, Wabash River	UC	4.4	0.8	-	
W. Terre Haute, Ind, Wabash River	UC	1.9	0.2	-	
England Pond, Ill, Wabash River	AP	6.0	-	-	
Island Levee, Ind, Wabash River	AP	9.3		-	

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Grassy Creek, Jackson Co, Ind	C	-	-	4.6
Portland, Ind, Salamonie River	C	-	-	4.4
Snagging and Clearing Projects				
Eel River, Clay Co, Ind	C			
Edwardsport, Ind, White River	C			

Table WA-2 (Cont'd)

JULY 1965 FLOOD CONTROL PLAN

WABASH RIVER BASIN

II. NON-FEDERAL

A. RESERVOIRS

None

B. LOCAL PROTECTION PROJECTS

Project Location	Status (5)	Remarks
Indianapolis, Ind, White River	C	Constructed by City of Indianapolis subsequent to authorization of Federal Project.
Indianapolis, Ind, Eagle Creek	UC	Completed by State of Indiana
Numerous Agricultural Levees	C	Compiled by local interests which provide various degrees of protection. Not shown on Figure WA-1

NOTES: (1) July 1965 Status: C - Completed AP - Authorized - advanced planning UC - Under construction

(2) Purpose: F - Flood control M - Water supply R - Recreation Q - Water quality

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention R - Recreation M&I - Municipal and industrial water supply F&WL - Fish and wildlife development

(5) Status of non-Federal projects as shown in Appendix J, "State Laws, Policies and Programs," Ohio River Comprehensive Survey C - Completed

Table WA-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

WABASH RIVER BASIN

	Average Annual Damages ($1,000)			
	Residual	Projected		
Area Location	1965	1980	2000	2020
Downstream	20,317	23,276	27,136	34,770
Upstream	16,076	21,698	29,357	37,215
Total Basin	36,393	44,974	56,493	71,985

Table WA-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

WABASH RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Lafayette	P	787	313.3	332.6
Lincoln	P	915	477.0	538.3
Patoka	P	168	144.1	324.8
Big Pine	P	331	201.5	210.5
Clifty Creek	P	140	48.6	56.2
Louisville	P	661	148.0	230.8
Helm	P	210	112.1	171.8
Big Walnut	P	197	160.7	323.4
Big Blue	P	269	75.1	120.1
Downeyville	P	276	71.3	161.9
Azalia	P	250	138.9	152.2
Deputy	P	294	103.0	147.0
Brouilletts	P	300	167.0	183.0
Coal Creek	P	244	156.6	170.2
Vernon Fork	P	226	76.7	112.8
Shoals	P	4,947	1,066.0	1,270.0
Parker City	P	175	42.7	133.0
Bean Blossom	P	167	105.0	114.0
Fortville	P	172	35.0	76.0
North Fork (Embarras River)	P	140	134.5	142.0
Fox River	P	84	50.0	54.5
Danville	P	970	361.0	413.0
Crawsfordsville	P	423	138.6	161.2
Denver	P	680	226.7	263.0
Perkinsville	P	542	34.0	69.0
Martinsville	P	2,430	550.0	633.0
Maltersville	P	56	44.8	73.3
Big Muddy	P	140	41.5	46.0
Tippecanoe	P	525	214.0	242.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Total Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
198	16,628	591	4,463	3,668,999	83,091	1,701

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Greenfield Bayou Levee, Wabash Riv, Ind	A	13.7	-	-	
Bonpas Creek Channel, Ill	A	-	-	11.2	
Levee Unit 2, Little Wabash River, Ill	A	8.4	-	0.4	
Levee Units 3 & 4, Wabash River, Ind	A	28.2	-	-	

Table WA-4 (Cont'd)

POTENTIAL FUTURE FLOOD CONTROL PLAN

WABASH RIVER BASIN

C. MAJOR LOCAL PROTECTION PROJECTS (Continued)

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Levee Unit 17, Wabash River, Ind	A	8.9	-	-	
Indianapolis, Ind, White River (Warfleigh Section)	I	5.9	0.8	5.9	Bridge Relocations
Orleans, Ind, Old Sulfur Sink	D	-	-	1.7	
Levee Unit 6, Wabash River, Ill	D	14.0	-	-	
Russell & Allison Levee, Wabash River, Ill	D	21.6	-	-	
Deer Cr Prairie Levee, Wabash River, Ind	D	3.7	-	-	
Levee Unit 1, Eel River, Ind	D	6.1	-	-	
Levee Unit 2, Eel River, Ind	D	14.8	-	12.8	
Levee Unit 1, Wabash River, Ill	D	14.7	-	-	
Levee Unit 1, Little Wabash River, Ill	D	21.5	-	-	
Levee Unit 1, White River, Ind	D	10.0	-	-	
Levee Unit 2, E. Fk White River, Ind	D	11.3	-	-	
Levee Unit 2, Wabash River, Ind	D	25.2	-	-	
Levee Unit 3, E Fk White River, Ind	D	28.4	-	-	
New Harmony, Ind, Wabash River	D	2.0	-	-	
Terre Haute, Wabash River, Ind	D	0.3	-	-	
Adams Levee, Wabash River, Ind	I	4.2	-	-	
Anderson, Ind, White River	I	1.2	0.1	-	
Clinton, Ind, Wabash River	I	0.5	-	-	
Fletcher & Sunshine Gardens, Ind, White River	I	4.7	-	-	
Honey Creek Levee, Wabash River, Ind	I	6.0	-	-	
Levee Unit 7, White River, Ind	I	10.8	-	-	
Levee Units 9, W Fk White River, Ind	I	0.4	-	-	
McGinnis Levee, White River, Ind	I	21.0	-	-	
Raccoon Levee, Wabash River, Ind	I	4.3	-	-	
Shoals, Ind, E Fk White River	I	1.6	-	-	
Shufflebarger Levee, White River, Ind	I	13.6	-	-	
Sugar Creek Levee, Wabash River, Ind	I	4.0	-	-	
Levee Unit 19, Wabash River, Ill	P	5.5	-	-	
Levee Unit 20, Wabash River, Ind	P	5.4	-	-	
Hazelton, Ind, White River	P	0.8	-	-	
Marion, Ind, Mississinewa River	P	1.1	0.2	-	

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Remarks
Rushville, Ind, Flatrock River	P	Channel improvement
Lawrenceville, Ill, Embarras River	P	Channel improvement proposed by State of Illinois
Skillet Fork River, Ill	P	Channel improvement proposed by State of Illinois
Crothersville, Ind, Muscatatuck River	P	Channel improvement

NOTES:

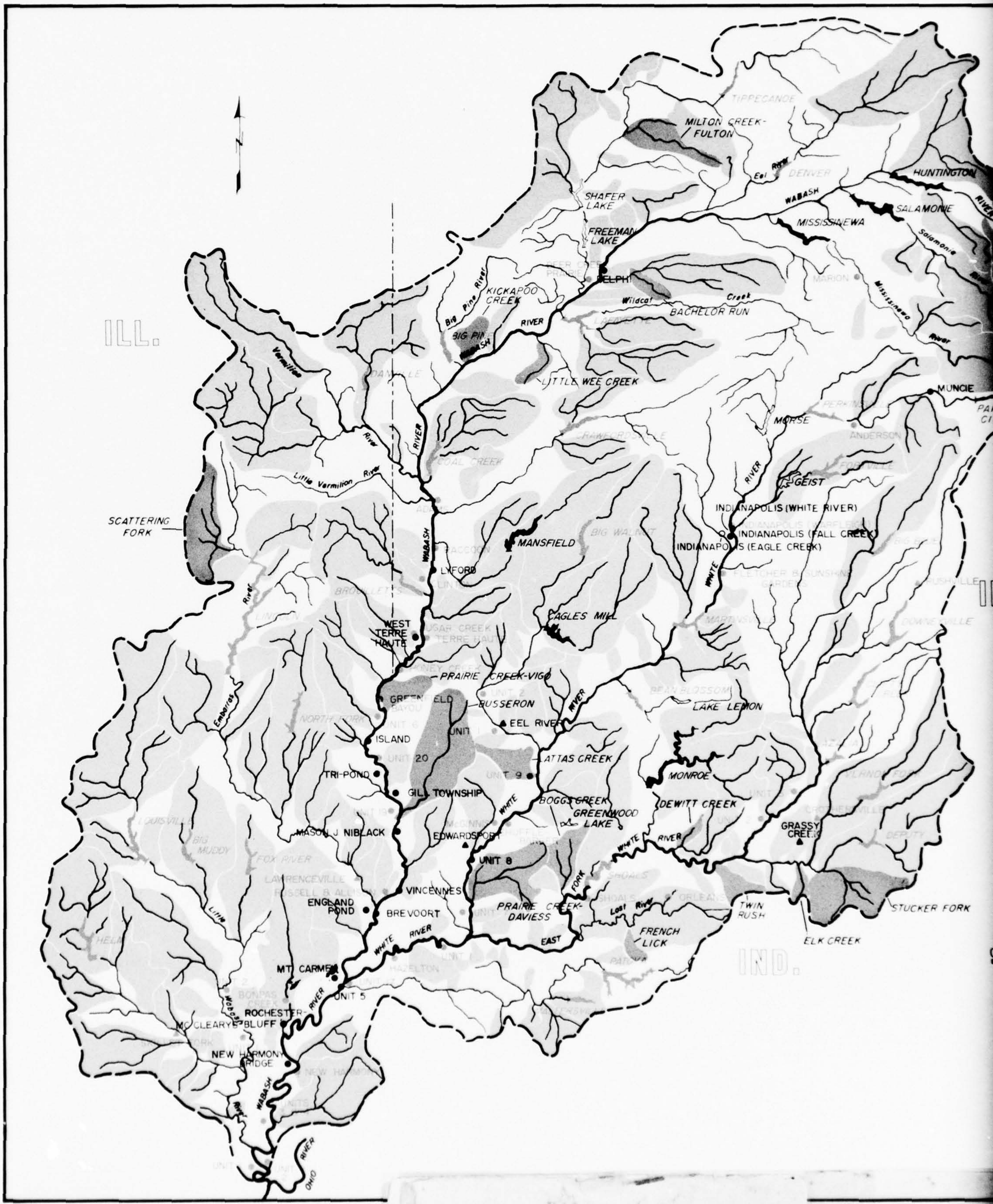
(1) July 1965 Status

A - Authorized project - Active status

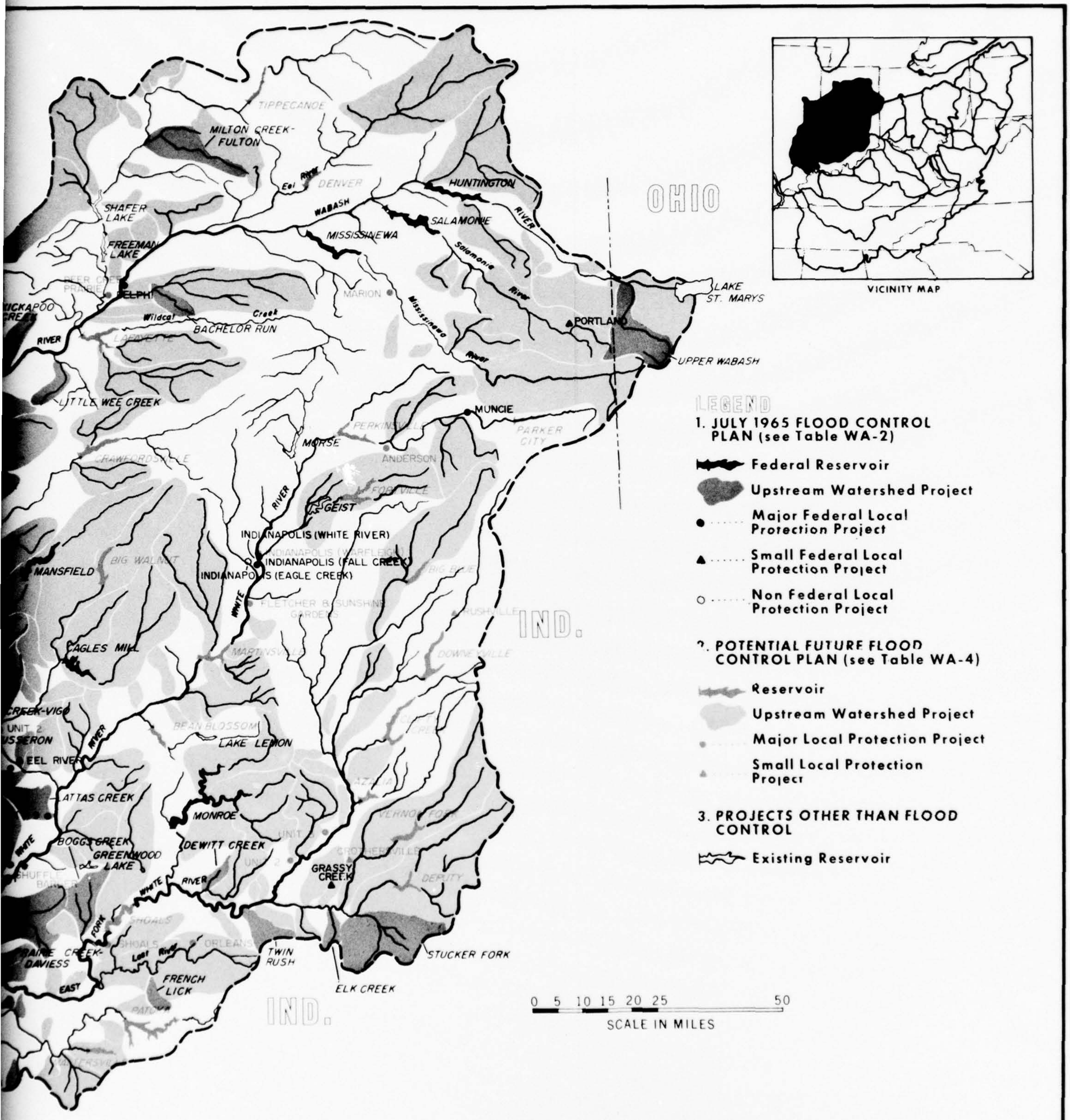
D - Authorized project - Deferred status

I - Authorized project - Inactive status

P - Potential project



ILL.
IND.
MILTON CREEK-FULTON
TIPPECANOE
HUNTINGTON
SALAMONIE
MISSISSINEWA
WABASH
SHAFER LAKE
FREEMAN LAKE
DELPHI
KICKAPOO CREEK
Big Pine River
BIG PINE
Wildcat Creek
BACHELOR RUN
RIVER
Vermilion
LITTLE WEE CREEK
MUNCIE
MORSE
Little Vermilion River
COAL CREEK
GEIST
SCATTERING FORK
MANSFIELD
INDIANAPOLIS (WHITE RIVER)
INDIANAPOLIS (FALL CREEK)
INDIANAPOLIS (EAGLE CREEK)
LYFORD
WEST TERRE HAUTE
CAGLES MILL
PRAIRIE CREEK-VIGO
GREENFIELD BAYOU
BUSSERON
EEL RIVER
LAKE LEMON
ISLAND
LATTAS CREEK
MONROE
TRI-POND
GILL TOWNSHIP
BOGGS CREEK
GREENWOOD LAKE
DEWITT CREEK
MASON J NIBLACK
EDWARDSPORT
GRASSY CREEK
UNIT 8
VINCENNES
ENGLAND POND
BREVOORT
PRAIRIE CREEK-DAVIESS
TWIN RUSH
STUCKER FORK
FRENCH LICK
ELK CREEK
WHITE RIVER
MT. CARMEL
UNIT 5
ROCHESTER-BLUFF
McCLEARYS
NEW HARMONY RIDGE
OHIO RIVER



OHIO RIVER BASIN COMPREHENSIVE SURVEY

WABASH RIVER BASIN
FLOOD CONTROL PROJECT
DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE WA-1

2

18. Cumberland River Basin

The Cumberland River Basin is located within Kentucky and Tennessee. The basin is somewhat crescent in shape, embracing a large part of southeastern Kentucky, the northern part of middle Tennessee, and a wide corridor across western Kentucky. It is bounded on the north by the watersheds of the Kentucky and Green Rivers and minor tributaries of the Ohio River, and on the south and west by the watershed of the Tennessee River. The total area of the Cumberland Basin approximates 17,920 square miles, of which 10,698 square miles are in Tennessee and 7,222 in Kentucky. Basin topography varies from rugged mountains in the eastern portion to a rolling low plateau in the western part, with elevations ranging from 4,150 feet above mean sea level in the Cumberland Mountains to 302 feet in the pool water at the mouth of the river. Average annual precipitation for the basin is in excess of 50 inches, with rainfall generally well distributed throughout the year, September and October being the minimum months and January and March the maximum months. The average annual snowfall for the watershed is 10 to 11 inches, with the greater amounts falling in the mountainous regions in the eastern section. Snow rarely stays on the ground more than a few days, except in the higher altitudes and usually contributes very little to floods in the basin.

The principal flood-producing storms are of the frontal type, and precipitation is generally widespread, of low intensity, and long duration. These storms are most prevalent during the months from October to April, inclusive. Thunderstorms have occurred in every month of the year throughout most of the basin but during the months of June, July and August, nearly every storm that occurs is of this type. Storms originating as tropical hurricanes have produced heavy rainfall over parts of the basin. Owing to the elongated shape of the basin and the path usually traversed by storms in the area, no single storm has ever produced a record flood throughout the length of the river. In general, most floods occurring on the Cumberland River below Wolf Creek Dam (Mile 460.9) are caused by prolonged storms extending over a large part of the watershed. On the upper Cumberland and on the tributaries, floods are generally the result of short, intense, isolated storms, or a succession of rains during a protracted storm period, falling on ground that has been saturated by previous rains. Record floods by reaches of the river below Wolf Creek Dam were experienced as follows: Mouth to Mile 160, January-February 1937; Mile 160 to 320, December 1926-January 1927; and Mile 320 to 460.9, March 1826. The flood history on this section of the river is characterized by frequent flooding, including 22 of major proportions since 1882. Serious flooding also has occurred repeatedly and frequently in the upper Cumberland River Basin. An extreme flood in January-February 1957 approached and exceeded in several localities the flood of January 1946 which produced record or near-record stages throughout the basin. Another flood occurring in March 1963 produced record crests at Harlan, Kentucky and other communities in that vicinity. Major floods of record were also experienced in 1918, 1926, 1929, 1948, 1951, 1955, and 1962. Flooding from relatively minor to disastrous proportions has been almost of annual occurrence at various locations

throughout the entire watershed. A recurrence of a composite of floods of record without the intervening development of control works would cause damages amounting to $15 million in downstream areas. Its damage would exceed that of the modified 100-year flood by 90 percent. (Table CU-1).

The July 1965 flood control plan is comprised of five reservoirs, five major and one small local protection project and six upstream watershed projects. (Table CU-2 and Figure CU-1). The flood control plan affords varying degrees of flood protection to about 79 percent of the basin's downstream flood plain and four percent of upstream flood plains. The completed reservoirs are Center Hill, Dale Hollow and Lake Cumberland (Wolf Creek). Under construction are Barkley and J. Percy Priest. These, acting as a system, prevent damages on the Cumberland main stem and contribute to flood stage reductions on the lower Ohio and Mississippi Rivers. The Barkley project is part of the authorized Cumberland navigation system.

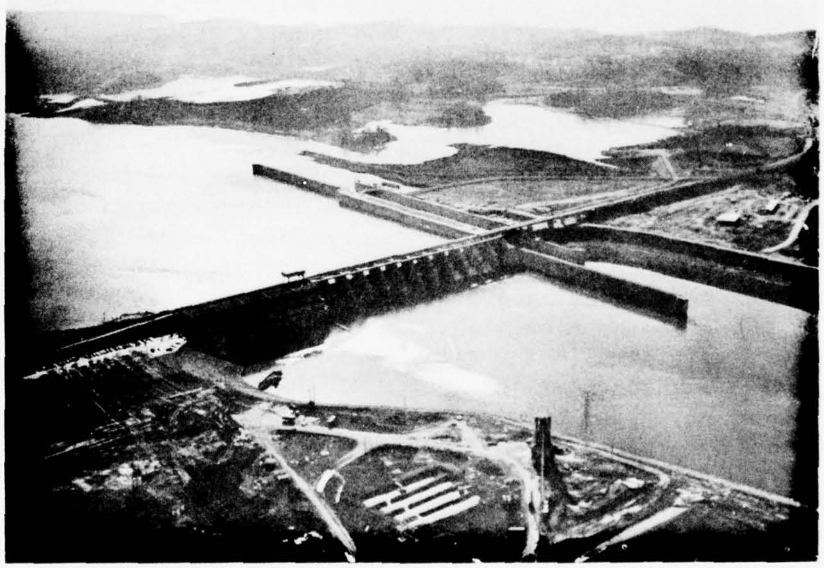


Photo 22. Barkley Multipurpose Project

Kentucky and Tennessee each has 3 authorized upstream watershed projects. These encompass an area of 306 square miles with runoff from about 151 square miles controlled by 24 retarding structures, which will provide storages of 18,500 acre-feet for floodwater detention and 2,500 for sediment. Their flood control cost is approximately $4.2 million and they will prevent about $235,000 in annual damages on 8,400 acres.

There are four major damage centers in the basin with annual flood losses ranging from $51,000 to $90,000. These are the localities of Harlan

Pineville, Loyall-Baxter and Barbourville, Kentucky. Harlan is located at the junction of Martins Fork and Clover Fork, Harlan County, upper Cumberland River Basin. A major flood at Harlan occurred in January 1946, resulting in 384 residences damaged more or less severely, and 12 destroyed; 49 commercial establishments suffered moderate to severe damages; and there was considerable damage to streets and utilities. An even larger flood occurred in March 1963. Just below Harlan on the Cumberland River are the small towns of Baxter-Loyall, which adjoin each other. These two communities are menaced only by high floods.

At Barbourville, existing protection works have substantially reduced the flood problem. Present residual average annual damages of about $59,000 occur mostly to areas outside the existing protection works. A similar situation exists at Pineville. The Martins Fork Reservoir included in the potential future program, would substantially alleviate the flood problem at Harlan and reduce flood damages significantly downstream on the Cumberland River as far as Barbourville.

A small flood protection project on Straight Creek and Left Fork Straight Creek consisting of minor channel clearing is being considered to alleviate the residual flood problem at Pineville. Other local flood protection projects being considered for the upper Cumberland Basin include improvements to stream channels at Evarts, Cawood, and Cumberland, Kentucky. The planned extension to the existing Middlesboro protective works would eliminate backwater flooding from Yellow Creek. The foregoing projects would prevent $147,000 in annual damages and protect 730 acres.

In downstream areas average annual damages of $515,000 are projected to increase to $1.1 million by 2020. (Table CU-3). Included in the potential future flood control plan for downstream areas are nine reservoirs and one major and 16 small local protection projects. (Table CU-4 and Figure CU-1).

Average annual damages of $4.3 million in upstream areas are expected to increase to $9.2 million by 2020 without further project development. (Table CU-3). Structural measures supplementing land treatment have been found to be potentially feasible in 45 additional upstream watersheds. (Table CU-4 and Figure CU-1). They would contain 775 miles of channel improvement and 258 retarding structures which could provide storage for 356,100 acre-feet of floodwater detention and 42,000 of sediment. The potential upstream watersheds would cover an area of 3,914 square miles, and their structures would control 1,571.

The average annual flood damages are $3.1 million with more than 43 percent of the damages attributable to agricultural crops. The damage per square mile of their watershed area is estimated at $800. The potentially feasible projects would reduce average annual damages in upstream areas by $2.5 million. They would protect 113,900 acres of flood plain, and their improvements would provide an opportunity for enhancing land values through an estimated annual $1.7 million increase in productivity.

As of September 1967, flood plain information studies have been completed at the following locations: along the Red and Cumberland Rivers in the vicinity of Clarksville, Tennessee; in the Murfreesboro, Tennessee area on Stones River; and on the Cumberland and Caney Fork Rivers at Carthage, Tennessee. In addition flood plain studies are underway at the following locations: along the Harpeth River at Franklin, Tennessee; at Celina, Tennessee, along the Cumberland River; and at Gainesboro, Tennessee, along Cumberland and Roaring Rivers and Jennings and Doe Creeks.

Table CU-1

FLOOD PLAIN DATA - CUMBERLAND RIVER BASIN

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Composite Historical Flood(2) Area Inundated (Acres)	Composite Historical Flood(2) Damages ($1,000)
Agricultural Crop	471	109		335		374
Agricultural Non-Crop	99	41		63		71
Residential	2,239	221		3,412		7,015
Commercial	1,516	79		2,410		5,294
Industrial	561	8		719		571
Other(3)	736	57		987		1,537
TOTAL	5,622	515	185,300	7,926	107,300	14,962

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	Category	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)
Crop and Pasture	1,905	1,845	Crop		25,781
Other Agriculture	269	261	Non-Crop		3,645
Transportation Facilities	577	542	Residential		2,642
Urban	833	748	Commercial and Industrial		5,791
Sediment and Erosion	331	305	Other(3)		11,836
Indirect(4)	634	613			
TOTAL	4,549	4,314	TOTAL	173,200	49,695

NOTES:
(1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: January 1946, February 1948, November 1956, January 1957, February 1961, March 1963.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

Table CU-2

JULY 1965 FLOOD CONTROL PLAN

CUMBERLAND RIVER BASIN

I. FEDERAL

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage Major Flood Season 1,000 Ac Ft	Flood Control Storage Major Flood Season Inches	Flood Control Storage Conservation Season 1,000 Ac Ft
Center Hill	C	F,P,R	2,174	2,092	838	7.3	762	6.6	762
Dale Hollow	C	F,P,R	935	1,706	857	17.2	353	7.1	353
Wolf Creek	C	F,P,R	5,789	6,089	1,853	6.0	2,094	6.8	2,094
Barkley	UC	F,P,R,N	7,808[3]	2,082	610	1.5	1,472w[4]	3.5	1,213s[4]
J. Percy Priest	UC	F,P,R	892	652	268	5.6	350w	7.4	260s

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose[5]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage Sediment (Ac Ft)	Storage Floodwater (Ac Ft)	Storage Other Uses (Ac Ft)	Storage Total (Ac Ft)	Channel Improvements (Miles)
Buck Creek, Ky	FP	120.1	3	89.1	975	6,740	-	7,715	10.0
North Fork, Little River, Ky	FP,M&I,F&WL	58.7	4	26.8	490	4,934	3,019	8,443	-
Proctor Creek, Tenn	FP	13.2	-	-	-	-	-	-	5.2
Pine Creek, Tenn	FP,M&I,F&WL	26.2	4	6.1	77	1,466	655	2,198	6.0
Meadow Creek, Ky	FP	15.4	-	-	-	-	-	-	7.4
Jennings Creek, Tenn	FP	72.1	13	29.3	930	5,442	-	6,372	19.0

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Barbourville, Ky, Richland Creek & Cumberland River	C	1.5	Minor	-	
Middlesboro, Ky, Yellow Creek	C	2.9	-	3.3	
Pineville, Ky, Cumberland River	C	0.7	1.2	-	
Corbin, Ky, Lynn Camp Creek	UC	-	-	2.0	Spoil bank
Cumberland, Ky, Poor Fork Cumberland River	UC	-	-	1.3	

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status
Snagging & Clearing Project	
Middlesboro, Ky, Yellow Creek	C

II. NON-FEDERAL

NONE

NOTES: (1) July 1965 Status: C - Completed UC - Under Construction

(2) Purpose: F - Flood control P - Hydro power R - Recreation N - Navigation

(3) Net drainage area below Center Hill, Dale Hollow, Wolf Creek, and J. Percy Priest Reservoirs

(4) w - Winter s - Summer

(5) Purpose: FP - Flood prevention M&I - Municipal and industrial water supply F&WL - Fish and wildlife development

Table CU-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

CUMBERLAND RIVER BASIN

	Average Annual Damages ($1,000)			
	Residual	Projected		
Area Location	1965	1980	2000	2020
Downstream	515	643	835	1,052
Upstream	4,314	6,330	7,545	9,190
Total Basin	4,829	6,973	8,380	10,242

Table CU-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

CUMBERLAND RIVER BASIN

A. RESERVOIRS

Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
Devils Jumps	P	957	256.0	4,136.0
Martins Fork	P	56	18.1	21.8
Kettle Island	P	46	14.9	19.7
Little Clear Creek	P	14	4.6	9.5
Letcher-Harlan	P	52	14.3	17.3
Presley House Branch	P	14	3.9	4.9
Clover Fork	P	29	7.6	11.1
Three Islands	D	854	351.0	715.0
Rossview	I	955	352.0	372.0

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
45	3,914	258	1,571	2,368,144	70,376	775

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Cumberland, Ky, Poor Fork	P	-	-	1.2

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Remarks
Pineville, Ky, Straight Creek	P	Channel improvement
Evarts, Ky, Clover Fork & Yocum Creek	P	Channel improvement
Cawood, Ky, Crummies Creek	P	Channel improvement
Middlesboro, Ky, Yellow Creek	P	Extension to existing improvements
Wallens Creek, Ky	P	Channel improvement
Heidrick, Ky, Big Richland Creek	P	Channel improvement
Artemus, Ky, Cumberland River	P	Channel improvement
Jellico, Tenn, Elk & Clear Fork Creeks	P	Channel improvement
McMinnville, Tenn, Barren Fork River	P	Channel improvement
Murfreesboro, Tenn, Lvtle & Sinking Creeks, West Fork Stones River	P	Channel improvement
Lynch, Ky, Looney Creek	P	Channel improvement
Benham, Ky, Looney Creek	P	Channel improvement
Stinking Creek, Ky	P	Channel improvement
Fourmile Creek, Ky	P	Channel improvement
Gainesboro, Tenn, Doe Creek	P	Channel improvement
Woodbury Tenn, East Fork Stones River	P	Channel improvement

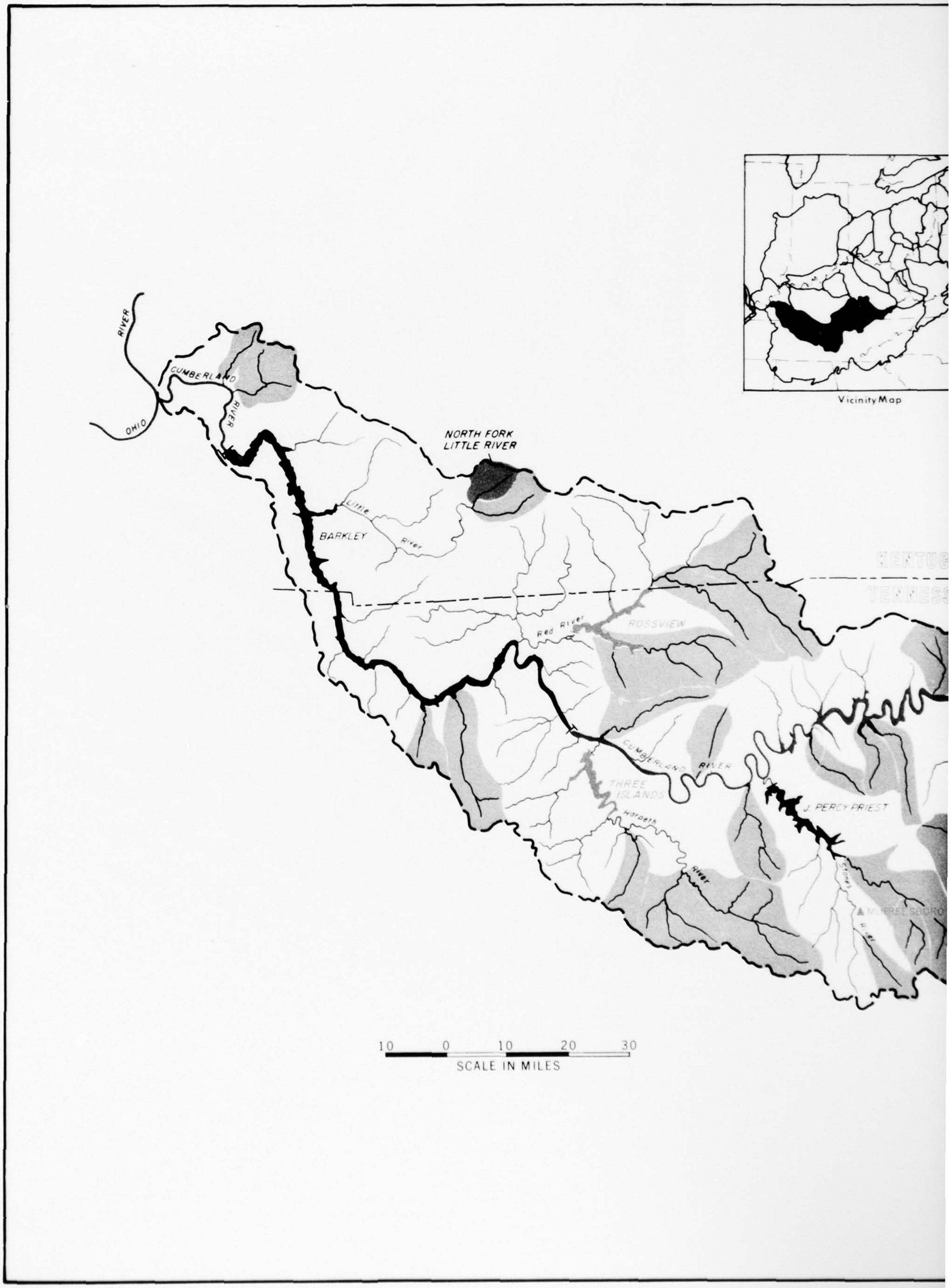
NOTES:

(1) July 1965 Status:

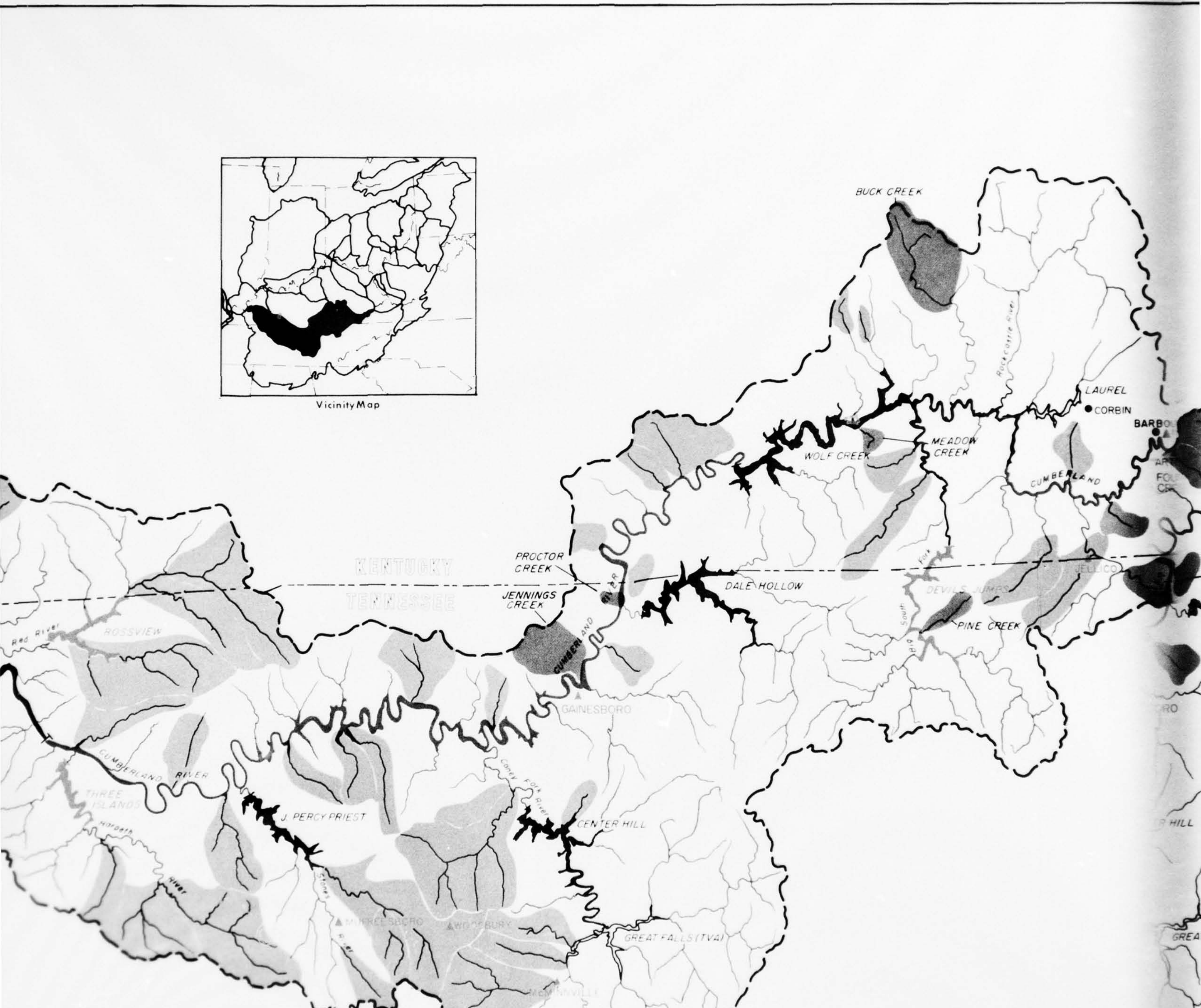
D - Authorized project - Deferred status

I - Authorized project - Inactive status

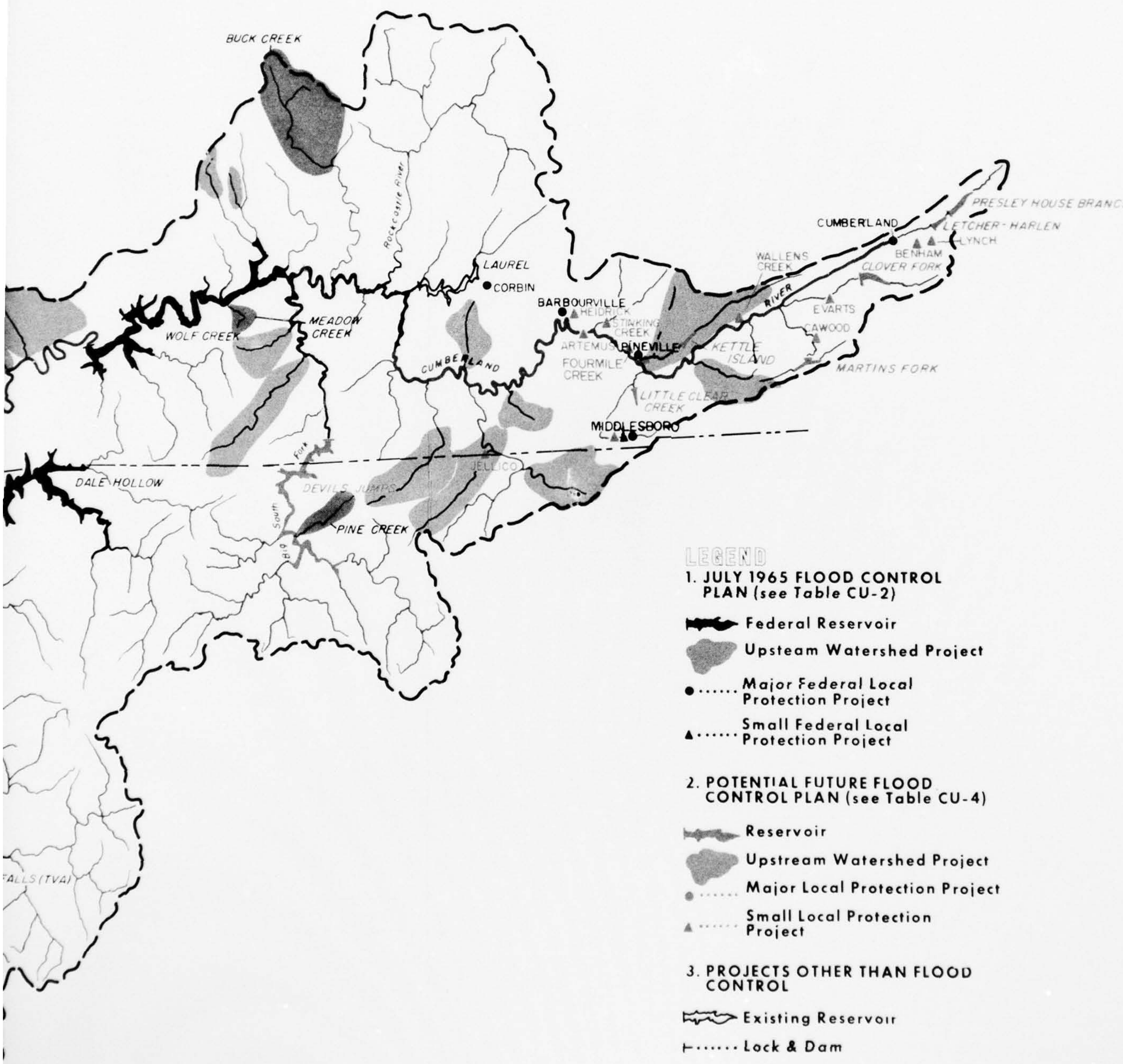
P - Potential project



OHIO
RIVER
CUMBERLAND
RIVER
NORTH FORK
LITTLE RIVER
Little
River
BARKLEY
Red River
ROSSVIEW
CUMBERLAND
RIVER
THREE
ISLANDS
Harpeth
River
J. PERCY PRIEST
Stones
River
Vicinity Map
10 0 10 20 30
SCALE IN MILES


Vicinity Map
BUCK CREEK
Rockcastle River
LAUREL
CORBIN
WOLF CREEK
MEADOW CREEK
CUMBERLAND
KENTUCKY
TENNESSEE
PROCTOR CREEK
JENNINGS CREEK
CUMBERLAND RIVER
DALE HOLLOW
DEVILS JUMPS
JELLICO
PINE CREEK
Red River
ROSSVIEW
GAINESBORO
CUMBERLAND RIVER
THREE ISLANDS
J. PERCY PRIEST
Caney Fork River
CENTER HILL
MURFREESBORO
WOODBURY
GREAT FALLS (TVA)

2



OHIO RIVER BASIN COMPREHENSIVE SURVEY

**CUMBERLAND RIVER BASIN
FLOOD CONTROL PROJECT
DEVELOPMENT AS OF JULY 1965**

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE CU-1

19. Ohio River Minor Tributaries

The minor tributary drainage areas, flanking the Ohio River and draining approximately 24,800 square miles, are situated in Pennsylvania, Ohio, West Virginia, Kentucky, Indiana, and Illinois. The topography of the minor tributary areas is greatly diversified. Generally in those areas near the mouth of the Ohio River, the surface is flat or rolling, while in those areas near the headwaters of the Ohio, the surface is rugged to mountainous. Between these areas there exists almost all varieties of surface relief.

Although there are no major urban damage centers in the minor tributary basins, the cumulative present residual annual damages amount to about $9.4 million. Because of their agricultural nature, most of the remaining damages ($8.8 million) are in upstream areas. (Table MT-1).

The July 1965 Federal flood control plan consists of four reservoirs, five major and 15 small local protection projects and 12 upstream watershed projects. (Table MT-2 and Figure MT-1). Seven of the 12 authorized upstream watershed projects are located in Kentucky, two in West Virginia, and one each in Ohio, Illinois, and Indiana. These encompass 999 square miles, and their impoundments control about 334 square miles of drainage area. Their retarding structures, when complete, will provide storages of 54,174 acre-feet for floodwater detention and 9,659 for sediment. The control cost amounts to $13.1 million, and they will prevent $554,000 in annual damage on 47,952 acres of flood plain.

The residual downstream average annual damages of $620,000 are expected to increase to about $1.6 million by 2020. (Table MT-3). The future downstream flood control program, consisting of 18 reservoirs and seven major and one small local protection project would substantially reduce the basin's 2020 average annual downstream damages. (Table MT-4 and Figure 0-3).

Average annual damages of $8.8 million in the upstream areas are expected to increase to $15.2 million by 2020 without further project development. (Table MT-3). Structural measures supplementing land treatment have been found to be potentially feasible in 113 additional upstream watersheds, of which 17 are located in Illinois; 40, Indiana; 11, Ohio; 3, Pennsylvania; 14, West Virginia; and 28, Kentucky. (Table MT-4 and Figure MT-1). They consist of 1,159 miles of channel improvement and 583 retarding structures which could provide storages of 483,100 acre-feet for floodwater detention and 72,500 for sediment. The average annual flood damages within these are estimated at $6.9 million, with about 56 percent attributed to agriculture crops. The damage per square mile of their watershed area is estimated at $788. The potentially feasible projects would reduce average annual damages in upstream areas by $5.5 million. They would protect approximately 425,800 acres of flood plain, and their improvements would provide an opportunity for enhancing land values through an estimated annual $4.3 million increase in productivity.

There are six authorized flood plain information studies in the minor tributary areas. Their status is as follows: a completed study on Pigeon Creek at Evansville, Indiana; studies underway at Paducah, Kentucky along Island and Perkins Creeks and along Mill, Pond and Beargrass Creeks in Louisville and Jefferson Counties, Kentucky; and a flood plain study authorized for Mill Creek at Ripley, West Virginia.

Because of the magnitude of the overall flood problem, brief discussions concerning flood problems and their potential solutions for some of the larger basins follow:

a. Middle Island Creek, West Virginia. The Middle Island Creek Basin is predominantly rural and sparsely populated. The main stem and its tributaries meander through narrow, winding valleys bounded by high and very steep ridges. The flood plain is narrow and is composed of farm land. Agriculture is steadily decreasing in the flood plain and each successive inundation causes less damage. Much of the land once was cultivated, but now it is out of production or used only for grazing. The lower 11 miles of Middle Island Creek is subject to Ohio River backwater flooding. The communities of Smithburg and West Union also have flood problems. The only existing flood protection work is a channel snagging and clearing project on Middle Island Creek at West Union. The Delong and Meathouse Fork potential reservoirs and upstream watershed projects appear to be a solution to the basin's flood problem. A study of survey scope of the basin is currently underway.

b. Twelvepole Creek, West Virginia. The Twelvepole Creek Basin is generally sparsely populated and primarily rural. Its main stem flood plain is relatively small. However, the basin is subject to flooding, particularly at Wayne.

The July 1965 Federal flood control plan includes the East Lynn and Beach Fork reservoirs. These two reservoirs will eliminate most of the damages, leaving an annual basin residual of about $166,000.

The potential Cabwaylingo Reservoir, upstream watershed projects, and rural levees appear to be practical solutions to the remaining flood problems on unprotected tributaries. Flood plain zoning may avoid some future problems.

c. Little Sandy River, Kentucky. The basin is predominantly rural and has a low population density. In the upper reaches, the main stream flows through a narrow gorge opening into a wide flood plain below Grayson. The communities of Grayson, Hitchens, and Williard have recurrent floods, and a chronic flood problem exists in agricultural areas.

The July 1965 Federal flood control plan consists of the Grayson Reservoir, and two local channel improvement projects. This reservoir, when completed, will virtually eliminate the flood problem at Grayson and greatly reduce downstream damages. The channel improvements are at Grahn on Little Sinking Creek and a snagging and clearing project for

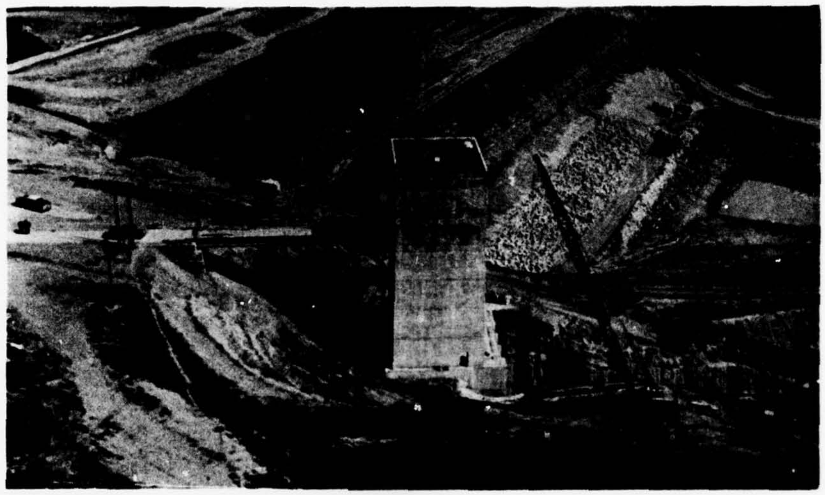


Photo 23. Aerial view of Grayson Dam looking across intake structure to right abutment showing construction of dam.

Hitchens on Little Fork. It appears that small reservoirs, upstream watershed projects, and channel improvements will provide practical solutions to the remaining flood problems.

d. Tygarts Creek, Kentucky. The basin is rural in nature and sparsely populated, and agricultural damages present the major flood problem. The lower 50-mile reach of the main stem is characterized by a wide and fertile flood plain which is generally subject to overflowing. Olive Hill is the only large city where flooding occurs.

The only existing flood protection project is a small channel improvement on Tygarts Creek at Olive Hill. This reduces annual flood damages there by 90 percent. The proposed Kehoe multipurpose reservoir on the main stem provides storages for flood and water quality control. Upstream watershed projects also appear as a solution to the flood problem in the basin.

e. Kinniconick Creek, Kentucky. Most improvements in the basin are located high enough to be above all but extreme flooding and the lower areas are not extensively used. Flood damages are relatively minor; most of them occur within the lower 40-mile main stem reach and could be prevented by the potential Kinniconick Reservoir and upstream watershed projects.

f. Whiteoak Creek, Ohio. Flood damages are relatively minor throughout the basin because of its agricultural nature. In the upper part of the basin, improvements are sparse, and a few small towns adjacent to streams occupy high ground above the area of frequent inundation. Watershed management programs and the potential Whiteoak Reservoir would provide the most efficient means of reducing flood losses.

g. Mill Creek Basin, Ohio. Mill Creek is within the Cincinnati Metropolitan Area and in recent years it has experienced extensive development, with this growth expected to continue. Headwater flooding has inflicted extensive damage along Mill Creek and several of its tributaries. The January 1959 flood, the highest of recent occurrence, caused $2 million in basin damages.

Local interests have completed extensive channel improvements, and the constructed West Fork Mill Creek Reservoir controls about 18 percent of the drainage area. Also, the Mill Creek barrier dam (see Table 0-5, under Ohio River Main Stem writeup) protects the flood plain against Ohio River backwater. Preliminary investigations have indicated that only limited reservoir potential exists in the basin. It appears that upstream watershed projects and channel improvements will provide practical solutions to the remaining flood problems.

h. Saline River Basin, Illinois. Authorized projects include the completed local protection project at Harrisburg, Illinois, and extensive channel improvement on the Saline main stem and tributaries, currently under construction. Flood damages are predominantly to agricultural properties and transportation routes. Several small localities also experience losses. In addition to this, the agricultural lands have drainage problems, and effluents from strip mines have caused loss of production. Construction of the authorized channel improvement would reduce but not eliminate present flood losses.

Solutions to residual problems include upstream watershed projects, improvement with local construction of laterals and field tiling. Three potential reservoirs could substantially reduce flooding and reduce the mine waste problem.

i. Tradewater River, Kentucky. The Tradewater River, located in northwestern Kentucky, drains about 995 square miles and flows into the Ohio River near Caseyville, Kentucky. The bottom lands are wide almost up to the sources of the river and of its tributaries. They average more than a mile in width on the main stream and half a mile on the larger tributaries. Much of the basin consists of cultivated farm lands and large wooded areas.

The basin is subject to headwater and to Ohio River backwater flooding. The most serious flooding is due to the latter. Sturgis, in Union County on the lower reaches of the Tradewater River, is subject to backwater flooding from the Ohio River. A local protection project which would afford protection to Sturgis from a flood equal to the

maximum of record (1937) is in the pre-construction planning stage. The project would protect about 670 acres of urban and suburban land and would include, as principle features, 3.3 miles of earth levee, two pumping plants, and related works.

Complete flood protection to the bottom lands could only be effected by a levee system, whose cost would far exceed the benefit realized. Protection to a degree from headwater flooding could be provided by the potential upstream watershed projects in the basin.

Table MT-1

FLOOD PLAIN DATA - OHIO RIVER MINOR TRIBUTARIES

(July 1965 Price Level)

A. DOWNSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)	Composite Historical Flood(2) Area Inundated (Acres)	Composite Historical Flood(2) Damages ($1,000)
Agricultural Crop	371	226		4,660		2,618
Agricultural Non-Crop	193	113		2,270		1,280
Residential	417	96		2,020		1,140
Commercial	302	51		1,023		570
Industrial	341	33		630		355
Other(3)	289	101		2,020		1,140
TOTAL	1,910	620	32,500	12,623	20,000	7,103

B. UPSTREAM AREAS

Category	Average Annual Damages ($1,000) Natural	Average Annual Damages ($1,000) Modified(1)
Crop and Pasture	4,749	4,502
Other Agriculture	379	368
Transportation Facilities	612	564
Urban	2,723	2,553
Sediment and Erosion	61	50
Indirect(4)	805	738
TOTAL	9,329	8,775

Category	100 Year Modified Flood(1) Area Inundated (Acres)	100 Year Modified Flood(1) Damages ($1,000)
Crop		16,837
Non-Crop		1,377
Residential		5,097
Commercial and Industrial		4,230
Other(3)		2,295
TOTAL	574,130	29,836

NOTES: (1) Modified by projects in the July 1965 flood control plan.
(2) Floods used for composite: March 1913, March 1924, February 1939, July 1943, July 1950, August 1952, October 1954, May 1956, January 1959.
(3) Other damages include: erosion and sedimentation other than agricultural, public properties and services, transportation facilities, communications, utilities, marine facilities, and relief and public health services.
(4) Indirect damages including interruptions to travel due to road damage, interruption of public utility service, inconvenience and hardships in repairing and replacing equipment and loss of business income.

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Table MT-2

JULY 1965 FLOOD CONTROL PLAN

OHIO RIVER MINOR TRIBUTARIES

I. FEDERAL

A. RESERVOIRS

Sub-Basin and Reservoir	Jul 65[1] Status	Purpose[2]	Drainage Area Controlled (Sq Mi)	Total Storage (1,000 Ac Ft)	Minimum Storage 1,000 Ac Ft	Minimum Storage Inches	Flood Control Storage: Major Flood Season 1,000 Ac Ft	Flood Control Storage: Major Flood Season Inches	Flood Control Storage: Conservation Season 1,000 Ac Ft
LITTLE SANDY RIVER, KY									
Grayson	UC	F,Q,R	196	119.0	15.4	1.5	100.3w[3]	9.6	89.6s[3]
MILL CREEK, O									
West Fork	C	F,R	30	11.4	1.5	1.0	9.9	6.3	9.9
TWELVEPOLE CREEK, W VA									
East Lynn	UC	F,R	133	82.5	11.7	1.6	70.8w	9.2	65.3s
Beech Fork	AP	F,R	78	37.5	4.2	1.0	33.3w	8.0	28.4s

B. UPSTREAM WATERSHED PROJECTS

Sub-Basin and Watershed Project	Purpose[4]	Project Area (Sq Mi)	Number of Structures	Drainage Area Controlled (Sq Mi)	Storage: Sediment (Ac Ft)	Storage: Floodwater (Ac Ft)	Storage: Other Uses (Ac Ft)	Storage: Total (Ac Ft)	Channel Improvements (Miles)
Middle Fork Anderson, Ind	FP,R	108.4	6	52.8	583	9,816	434	10,833	34.4
Canoe Creek, Ky	FP	119.8	10	13.6	420	1,682	-	2,102	29.5
Humphrey-Clanton, Ky	FP	107.1	5	26.1	528	4,529	-	5,057	25.0
Little Kentucky River, Ky	FP,R	71.2	6	29.1	604	5,163	1,699	7,466	-
Upper Grave Creek, W Va	FP,M&I	7.7	7	2.0	39	387	129	555	3.6
West Fork Duck Creek, O	FP,R,M&I	106.8	8	39.9	2,618	8,838	4,937	16,393	19.9
Crab Orchard, Ky	FP	151.4	13	35.8	651	3,987	-	4,638	31.6
Cypress Creek, Ky	FP,R	50.7	3	3.0	103	578	389	1,070	6.0
Donaldson, Ky	FP,R	73.5	7	33.0	500	5,161	543	6,204	31.1
Upper Tradewater, Ky	FP	93.7	8	53.0	2,189	7,549	-	9,648	13.9
Little Cache, Ill	FP	70.3	5	25.9	892	3,447	-	4,339	16.0
Harmon Creek, W Va & Pa	FP,F&WL	38.0	14	19.7	532	3,127	981	4,640	-

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel	Other
Harrisburg, Ill, Middle Fork, Saline River	C	3.8	0.1	-	
Reevesville, Ill, Bay Creek	C	8.4	-	-	
Washington, Pa, Chartiers Creek	C	0.2	-	1.7	
Sturgis, Ky, *Tradewater River*	AP	3.3	-	-	
Saline River & Tribs, Ill	AP	-	-	51.9	15.4 clearing and snagging

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Olive Hill, Ky Tygarts Creek	C	-	-	1.7
Grahn, Ky, Little Sinking Creek	C	-	-	1.3
English, Ind, Little Blue River	C	-	-	3.4
Corydon, Ind, *Indian & Little Indian Creeks*	C	-	-	4.4
Amsterdam, Ohio, Yellow Creek	C	-	-	0.8
Leetonia, Ohio, Cherry Valley Run	C	-	-	1.4
Burgettstown, Pa, Burgetts Fork, Raccoon Creek	C	-	-	2.0
Slovan, Pa, Burgetts Fork, Raccoon Creek	C	-	-	1.8

Snagging & Clearing Projects

Huntington, W Va, Fourpole Creek	C
West Union, W Va, Middle Island Creek	C
Jacksonburg, W Va, Fishing Creek	C
Smithfield, W Va, Fishing Creek	C
Colliers, W Va, Harmon Creek	C
Hitchens, Ky, *Little Fork, Little Sandy River*	C
Pine Grove, W Va, Fishing Creek	UC

II. NON-FEDERAL

A. RESERVOIRS

NONE

B. LOCAL PROTECTION PROJECTS

Project Location	Status[5]	Type of Project and Length in Miles: Earth Levee	Concrete Flood Wall	Channel
Darlington, Little Beaver Creek	C	0.4	-	0.4

NOTES: (1) July 1965 Status C - Completed UC - Under construction AP - Advanced Planning

(2) Purpose: F - Flood control Q - Water quality R - Recreation

(3) w - Winter s - Summer

(4) Purpose: FP - Flood prevention R - Recreation M&I - Municipal and industrial water supply
F&WL - Fish and Wildlife development

(5) Status of non-Federal projects as shown in Appendix J, "State Laws, Policies and Programs," Ohio River Basin Comprehensive Survey
C - Completed UC - Under construction

Table MT-3

PROJECTED AVERAGE ANNUAL FLOOD DAMAGES

MINOR OHIO RIVER TRIBUTARIES

	Average Annual Damages ($1,000)			
	Residual	Projected		
Area Location	1965	1980	2000	2020
Downstream	620	732	1,079	1,570
Upstream	8,775	9,878	12,561	15,252
Total Minor Tributaries	9,395	10,610	13,640	16,822

Table MT-4

POTENTIAL FUTURE FLOOD CONTROL PLAN

OHIO RIVER MINOR TRIBUTARIES

A. RESERVOIRS

Sub-Basin & Reservoir	Jul 65[1] Status	Drainage Area Controlled (Sq Mi)	Flood Control Storage (1000 Ac Ft)	Total Storage (1000 Ac Ft)
TWELVEPOLE CREEK, W VA				
Cabwaylingo	P	40	19.3	21.4
WHITEOAK CREEK, OHIO				
Whiteoak	P	214	71.5	99.5
MIDDLE ISLAND CREEK, W VA				
Delong	P	554	190.0	195.0[3]
Meathouse Fork	P	50[3]	27.0	30.0[3]
KINNICONICK CREEK, W VA				
Kinniconick Creek	P	253	85.8	106.3
TYGARTS CREEK, KENTUCKY				
Kehoe	P	127	65.6	79.0
SALINE RIVER, ILLINOIS				
Stonefort	P	30	30.0	35.0[3]
Bushy Creek	P	22	24.0	30.0[3]
Bear Creek	P	48	55.0	60.0[3]
MILL CREEK, W VA				
Ripley	P	130	55.0	60.0[3]
OHIO BRUSH CREEK				
Buzzardsroost	P	402	171.0	173.0
CACHE RIVER				
Dam No. 2, Cache River	P	40	12.0	13.0[3]
Dam No. 3, Cache River	P	38	4.6	5.0[3]
Dam No. 4, Cache River	P	8	1.5	2.0[3]
Dam No. 5, Cache River	P	10	11.0	12.0[3]
Dam No. 6, Cache River	P	6	1.1	1.5[3]
Dam No. 7, Cache River	P	2	1.0	1.5[3]
Dam No. 8, Cache River	P	2	0.6	1.0[3]

B. UPSTREAM WATERSHED PROJECTS

Number of Projects	Area in Potential Watersheds (Sq Mi)	Number of Potential Structures	Area Above Structures (Sq Mi)	Total Storage Potential (Ac Ft)	Potential Surface Area (Acres)	Estimated Flood Channel Improvements (Miles)
113	8,749	583	2,721	2,210,843	81,788	1,159

Table MT-4 (Cont'd)

POTENTIAL FUTURE FLOOD CONTROL PLAN

OHIO RIVER MINOR TRIBUTARIES

C. MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project & Length in Miles			
		Earth Levee	Concrete Flood Wall	Channel	Other
Bridgeville & Carnegie, Pa, Chartiers Creek	D	-	-	11.3	Includes 0.8 miles of Channel Cutoff
Canonsburg & Houston, Pa, Chartiers Creek	D	-	-	4.7	
Washingtonville, Ohio, Cherry Valley Run[2]	D				
Wheeling Creek, W Va[2]	D				
Adena, Ohio, Short Creek	D	0.1	-	1.0	
Dillonvale, Ohio, Short Creek	D	-	-	2.1	
Wayne, W Va, Twelvepole Creek	P	-	-	2.8	

D. SMALL LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Remarks
Oakdale, Pa, Robinson Run	I	Channel Improvement

NOTES:

(1) July 1965 Status

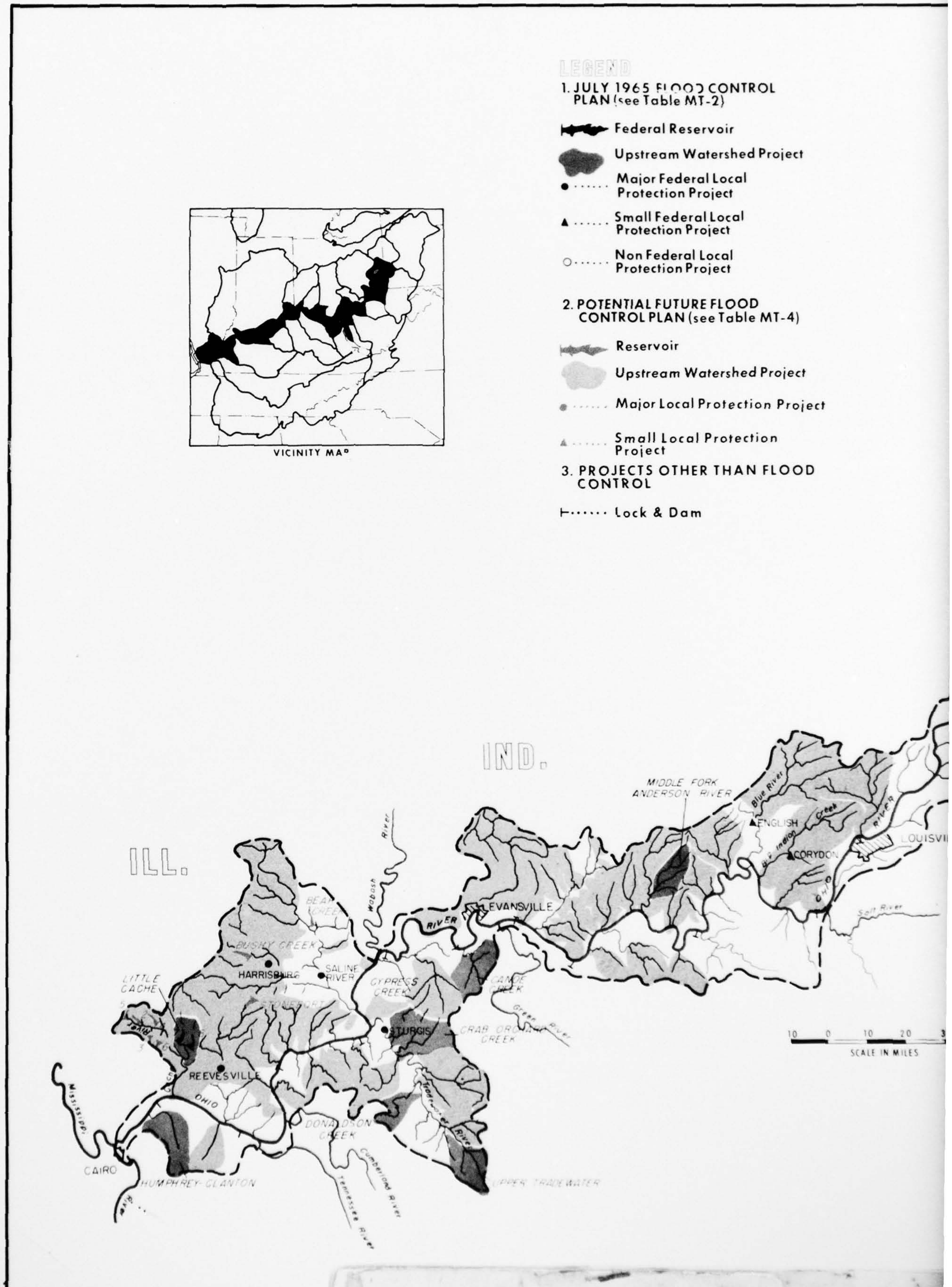
D - Authorized project - Deferred status

I - Authorized project - Inactive status

P - Potential project

(2) Project dimensions not defined at this time

(3) Estimated


LEGEND
1. JULY 1965 FLOOD CONTROL PLAN (see Table MT-2)
Federal Reservoir
Upstream Watershed Project
Major Federal Local Protection Project
Small Federal Local Protection Project
Non Federal Local Protection Project
2. POTENTIAL FUTURE FLOOD CONTROL PLAN (see Table MT-4)
Reservoir
Upstream Watershed Project
Major Local Protection Project
Small Local Protection Project
3. PROJECTS OTHER THAN FLOOD CONTROL
Lock & Dam
VICINITY MAP
IND.
ILL.
MIDDLE FORK ANDERSON RIVER
Blue River
ENGLISH
CORYDON
LOUISVI
Salt River
OHIO
EVANSVILLE
RIVER
Wabash River
BEAR CREEK
BUSHY CREEK
HARRISBURG
SALINE RIVER
LITTLE CACHE
CYPRESS CREEK
CANOE CREEK
Green River
STURGIS
CRAB ORCHARD CREEK
REEVESVILLE
OHIO
Mississippi
DONALDSON CREEK
Cumberland River
Tennessee River
CAIRO
HUMPHREY-CLANTON
UPPER TRADEWATER
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FLOOD CONTROL
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Local Protection Project
Local Protection
t
OTHER THAN FLOOD
Dam
N
OHIO
KY.
W. V
WEST FORK
DUCK CREEK
Muskingum River
MARIETTA
Little Muskingum
Hocking River
PT. PLEAS
Little Kanawha
Great Miami River
Little Miami River
WEST FORK
CINCINNATI
Licking River
Kentucky River
LITTLE KENTUCKY RIVER
LOUISVILLE
Blue River
ENGLISH
Big Indian Creek
CORYDON
OHIO
RIVER
Salt River
DDLE FORK
RSON RIVER
WHITEOAK
Ohio Brush Creek
Scioto River
PORTSMOUTH
Raccoon Creek
KINNICONICK CREEK
Tygarts Creek
Little Sandy River
OLIVE HILL
GRAHN
HITCHINS
GRAYSON
Big Sandy River
HUNTINGTON
BEECH FORK
WAYNE
EAST LYNN
Guyandotte River
Kanawha
River
10 0 10 20 30 40
SCALE IN MILES

2

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OHIO RIVER BASIN COMPREHENSIVE SURVEY. VOLUME XIV. APPENDIX M. --ETC(U)

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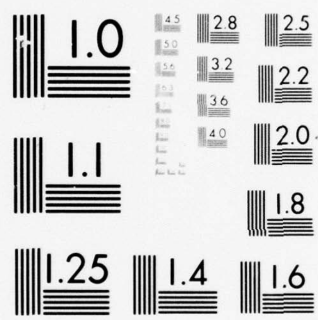
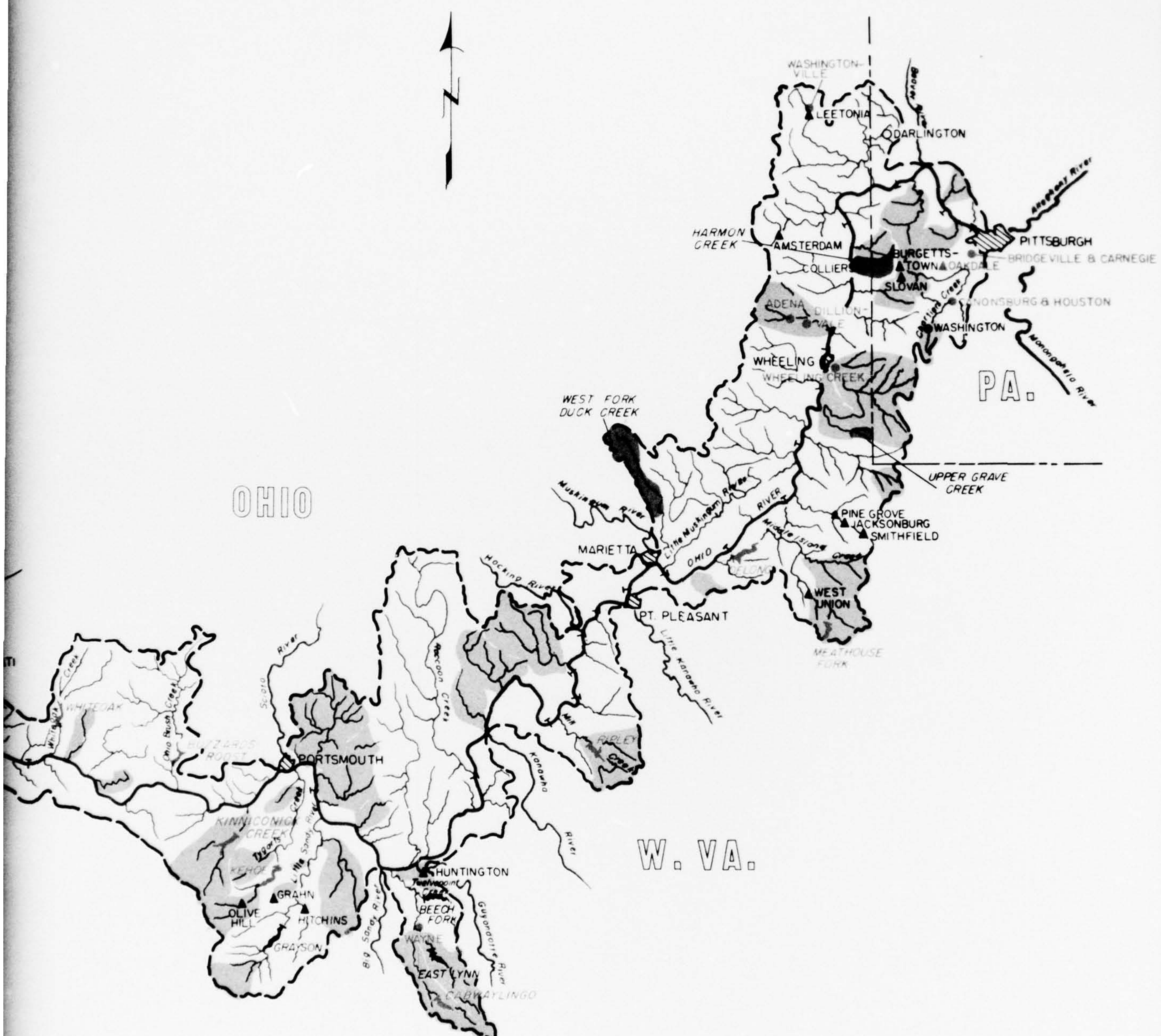


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



OHIO RIVER BASIN COMPREHENSIVE SURVEY

OHIO RIVER MINOR TRIBUTARIES FLOOD CONTROL PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION
APPENDIX M FIGURE MT-1

20. Ohio River Main Stem

The first record of serious floods on the Ohio River is contained in a letter of Colonel Henry Bouquet, the English commandant of Fort Pitt, now Pittsburgh. It describes the flood of 1763 which apparently attained a stage of about 41 feet if correlated to the present Pittsburgh gage. This was probably the maximum stage at Pittsburgh until the 46-foot flood of March 1936. There is also a legendary record of a 75 to 76 foot stage that occurred at Cincinnati around 1773. If so, this has been exceeded only by the 80-foot stage of the January-February 1937 flood. The February 1884 flood established for many years the record at numerous localities along the Ohio River from the mouth of the Beaver River downstream to below Paducah, Kentucky. The March 1907 flood was a major one confined to the upper portion of the Ohio, but did not reach extreme high stages below Wheeling, West Virginia.

The great floods of modern record along the Ohio River, preceding any significant progress on Federal flood control works, occurred in March 1913, March 1936, and January-February 1937. The 1937 flood is the flood of record in the 715-mile reach from the mouth of the Kanawha at Point Pleasant, West Virginia, to the mouth of the Ohio at Cairo, Illinois. The 1913 flood is the greatest of record from New Martinsville, West Virginia, 147 miles downstream to the mouth of the Kanawha River. For the 119-mile reach from Pittsburgh to near New Martinsville, the 1936 flood is the maximum of record. Figure 0-1 shows relative stage profiles for these and the 1964 flood along the Ohio River. The recurrence of a flood equalling the composite of the 1913, 1936 and 1937 ones would cause damages of $1.84 billion and would inundate more than 1.1 million acres of flood plain if it were not for the intervening development of control works. (Table 0-1). The damages would be almost six times as great as those that would result from the modified 100-year flood. (Table 0-2). Figure 0-4 shows the location of Ohio River flood damage reaches.

Industrial and other developments have concentrated in the flood plain of the Ohio River to take advantage of water supply and favorable location with respect to river and land transportation. These developments make it impracticable to construct main stem storage reservoirs as has been done in some of the country's other major river basins. Similar conditions exist on many of the Ohio's principal tributaries. The Ohio River has an unusually wide range in stages. The extreme high water reached a stage of 80 feet at Cincinnati during the 1937 flood, 28 feet above the stage at which overbank flooding begins. Consequently, it is highly desirable to reduce flood stages by means of reservoirs in order to reduce the expense of high levees and floodwalls at damage centers. Any reductions of flood stage that can be obtained by reservoirs are also beneficial to rural and moderately developed areas along the main stem. Flood plains in these areas are generally narrow, the result being that their damages per unit of valley length are not sufficient to justify construction of high protection works.

Following the flood of January-February 1937, studies to develop a flood control plan for the basin were made, including the determination of a project flood for the Ohio River. This was derived as the maximum anticipated flood which would be caused by combinations of the severest general storms that have occurred in the various regions of the basin. It is similar in nature, but of lesser magnitude than a Standard Project Flood (SPF). The system of reservoirs authorized by the 1938 Flood Control Act and prior acts would reduce the 1937 project flood to stages very close to the maximum of record along the Ohio River from Wellsville, Ohio, to the mouth and below stages of the flood of record between Pittsburgh and Wellsville. The project design flood profile then selected in 1937 for construction of local protection works on the Ohio was established as the modified project flood between Pittsburgh and Wellsville and as the maximum flood of record between Wellsville and the mouth of the Ohio River at Cairo. Local protection works constructed since 1937 provide three feet of freeboard above the grade of the project design flood profile.

In light of the accumulated experience, the latest developments in meteorologic and hydrologic techniques and currently available data, a reappraisal of the 1937 project flood was required. In conjunction with the present comprehensive survey, a SPF has been developed for the Ohio River from standard project storms. The procedure used is explained in Appendix C, Hydrology. Stages for the SPF (natural) range from about four to 18 feet above the maximum floods of record. (Figure O-2 and Table O-3).

Those reservoirs in the July 1965 Federal flood control plan (those constructed, under construction, and in preconstruction planning as of July 1965), as listed in the preceding sub-basin discussions will reduce the SPF stages throughout the Ohio River with the modified stages ranging from about three feet under at Pittsburgh to ten feet above the project design profile (the maximum flood of record) at St. Marys, West Virginia. (Figure O-2 and Table O-3). Table O-4 gives historical flood stage and discharge reductions along the Ohio River, assuming the flood control plan is in operation. In terms of average annual damage reductions, the tributary reservoirs and the local protection projects along the Ohio River (Table O-5) have reduced the average annual damages along the Ohio from $100 million to $11 million. (Table O-6).

Projected economic conditions in the flood plains are expected to increase this $11 million average annual residual flood damage to about $45 million by 2020. (Table O-7). The potential future flood control program for the Ohio River, consisting of 161 tributary reservoirs and 26 Ohio River local protection projects, would substantially reduce the projected 2020 main stem damages. The 161 tributary reservoirs are tabulated and shown in the 19 preceding major sub-basin discussions. The 26 local protection projects are tabulated in Table O-8 and shown on Figure O-3.

In terms of stage reduction of the SPF profile for those reservoirs included in the present and potential future flood control plans, modified

stages of the SPF profile would range from minus 11.7 feet at Pittsburgh to plus 4.2 feet above the maximum flood of record profile at St. Marys, West Virginia. To reduce further the SPF to the maximum of record profile, flood control storages of about 14 million acre-feet, above that contained in the present and potential future plans, would be required. (Table 0-9).

Regulation of the Ohio River flood flows by reservoirs is governed by observed or predicted stages at one or more tributary points. Secondary control points on the main stem also govern, especially with respect to release of stored flood flows. These regulations are established prior to the completion of projects, based on studies and procedures that give the maximum amount of crest reduction for a representative series of record and hypothetical floods. Tributary flows are regulated to obtain main stream flood reductions even though the tributary flows may be predicted not to reach stages which otherwise would not require storage of flows. Reservoirs built primarily for Ohio River control are regulated to obtain maximum crest reduction within the limits of flood control capacity.

The Ohio River and its backwater areas have been divided into 16 major reaches (OR 1-16) in order to identify areas having flood problems. See Figure 0-4. For reporting purposes, they have been consolidated into upper, middle and lower major Ohio River damage sections. These sections correspond with Corps District boundaries of Pittsburgh, Huntington, and Louisville. Ohio main stem major damage centers are listed in Table 3 of Section 1 and discussed in subsequent Ohio River sections.

Upper Section of the Ohio River

Numerous small river communities are flooded by the Ohio and incur damages. However, the major damage centers are the Pittsburgh Metropolitan Area, Pennsylvania; Wheeling, West Virginia; and Steubenville, Ohio. They comprise about 70 percent of the damages in this section.

The Pittsburgh Metropolitan Area's annual flood damages, mostly from commercial establishments, amount to about $1 million most of which is along the Allegheny and Monongahela Rivers. An authorized, not started, local protection project comprised of three segments called the Golden Triangle, North Side and the Strip, totaling about 60,000 feet of floodwalls, would virtually eliminate current residual damages. This is currently inactive because it lacked economic justification and there was inadequate local interest when last investigated. Recent major developmental changes have occurred in the flood plains that might favorably affect economic feasibility. Flood damage reductions would also come from the construction of additional tributary reservoirs above Pittsburgh.

Most of the annual damages of about $329,000 in the vicinity of Wheeling are residential, but commercial and industrial developments sustain significant losses. A three segment authorized, not started, local protection project, Wheeling-Benwood, North Wheeling, and Wheeling Island, with 30,000 feet of levees and 25,000 feet of floodwalls, could alleviate the problem. This is currently inactive because of lack of adequate local sponsorship; however, it appears to be economically feasible at this time.

About $53,000 in annual flood damages are sustained in Steubenville. There has been no recent study of the area, and economic justification of any project there would be questionable.

Middle Section of the Ohio River

This section, extending from near Powhatan Point, Ohio, downstream 329 miles to the vicinity of Foster, Kentucky, comprises Ohio River reaches OR 9-12. See Figure 0-4. The March 1913 flood is the maximum of record for OR 11-12, in the upper part of the section. In OR 9-10 the January-February 1937 flood is the record. The storm that caused the 1913 Ohio River flood was centered over the Beaver, Muskingum, Scioto, Great Miami and Wabash Basins. Tributaries south of the Ohio contributed only moderate flood flows. At Parkersburg a peak stage of 58.9 feet, about 23 above flood state, was recorded in 1913. The 1937 flood was caused by excessive and almost continuous rainfall for a 20-day period over the entire basin. At Portsmouth, this flood caused a record height of 75.3 feet, about 25 feet above flood stage and its peak discharge reached 693,000 cfs.

Although numerous river towns are susceptible to minor flooding, the major damage centers are New Martinsville, West Virginia, and Marietta, Ohio. These constitute about 15 percent of the damages in this section. More than one-half of New Martinsville's annual flood damages of $269,000 are residential. An authorized, not started, local protection project consisting of 5,800 feet of levee and 5,500 of floodwall would eliminate almost all of its damages. A recent study of the project found it not economically feasible. Marietta's flood damages of $130,000 annually could be alleviated by an authorized, not started, local protection project of levees and floodwalls.

Lower Section of the Ohio River

This section consists of reaches OR 1-8 beginning near Foster, Kentucky, to the mouth of the Ohio at Cairo, Illinois, 543 miles downstream. The 1937 flood is the record throughout this area. Record flood stages at Cincinnati, Louisville, and Paducah reached 80.0, 85.0, and 60.6 feet respectively. These are 28, 30.4 and 21.6 feet above flood stages. Peak discharges reached 892,000 cfs at Cincinnati and 1,850,000 cfs at Paducah.

Major flood problems in this section have been largely reduced by construction of local protection works at the more severly damaged areas. Tributary reservoirs have reduced flooding conditions at other areas. The remaining major flood damage centers are Cincinnati, Ohio; Aurora and Evansville, Indiana; Southwest Jefferson County and Dayton, Kentucky, with average annual damages amounting to $442,000 at Cincinnati, $245,000 at Aurora, $176,000 at Evansville, and $125,000 at Dayton.

An authorized, not started, flood protection project, Cincinnati Unit 4, consisting of 2.4 miles of floodwall along the Front Street area, would alleviate much of the problem. When last studied, this was not justified economically.

The authorized local protection project of levees and floodwalls at Aurora is classified deferred, with a feasibility study under way. At Evansville, the Pigeon Creek Section Unit 2 and Howell Unit 2, consisting of levees and floodwalls, would alleviate most of the damages. A recent feasibility study found the Pigeon Creek Section justified, but Howell Section not justified.

In Southwest Jefferson County, the flood problem area comprises about 41 square miles along the Ohio River, lying between the existing local protection project at Louisville, Kentucky, and the Salt River. About 30 percent of the area has been developed as suburban to Louisville. Currently, a survey scope report of the area is underway. Constructing the authorized Dayton local protection project consisting of levees and floodwalls is deferred. The last study of the area found the project not economically feasible. The study currently underway indicates the project to be marginal.

As of September 1967, there are five areas where flood plain information studies are underway in this portion of the Ohio River. These are located in the areas of Louisville and Paducah, Kentucky; two in the vicinity of Cincinnati, Ohio; and one, along the Ohio and Licking Rivers in Campbell and Kenton Counties, Kentucky, including Dayton, Kentucky. These will be valuable sources for data on flood problems within their respective areas. The studies at Cincinnati and Dayton are of particular interest because these are major flood damage centers. The Cincinnati studies cover the Ohio River limits of Clermont and Hamilton Counties, lower 8.7 miles of the Great Miami River, and lower 1.8 miles of the Whitewater River.

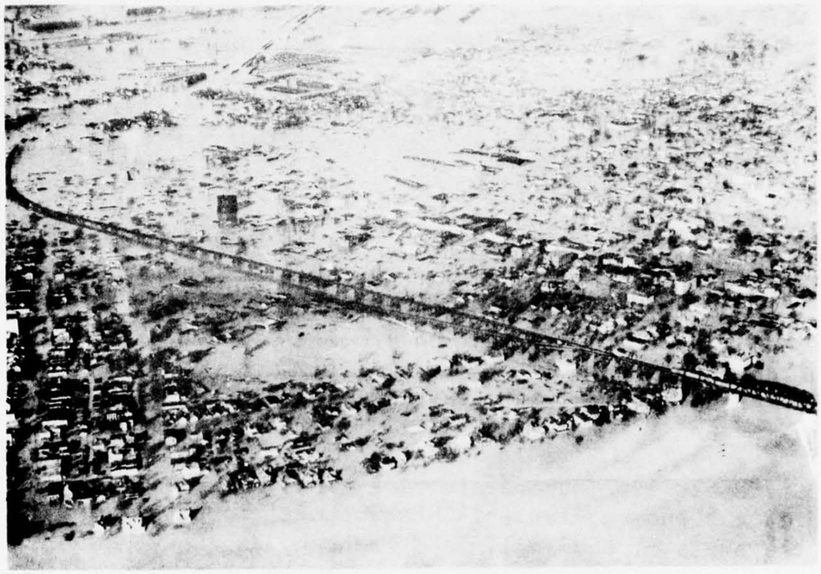


Photo 24. January - February 1937 Flood at Jeffersonville, Indiana.

Photo 25. Protected Area of Jeffersonville, Indiana, during the March 1945 Flood.

Table 0-1

PERTINENT FLOOD PLAIN INFORMATION ON FLOODS OF RECORD

OHIO RIVER MAIN STEM

Reach(1)	Flood of Record	Area Inundated (1000 Acres)	Natural Damages ($1,000) Crop	Non-Crop	Residential	Commercial	Industrial	Other	Total
						LOWER SECTION			
OR-1	Jan-Feb 1937	118.5	231	723	47,277	21,894	3,879	8,672	82,676
OR-2	"	327.0	728	2,678	11,700	4,193	331	4,032	23,662
OR-3	"	257.3	549	1,333	44,403	20,813	8,024	8,701	83,823
OR-4	"	142.7	316	6,554	14,618	2,058	792	1,594	25,932
OR-5	"	58.5	62	2,848	325,206	82,741	113,754	81,954	606,565
OR-6	"	31.7	66	606	16,782	9,877	10,997	6,552	44,880
OR-7	"	21.9	27	1,989	49,766	32,123	75,479	21,378	180,762
OR-8	"	10.2	19	1,921	9,658	3,085	747	4,254	19,684
Sub-Total		967.8	1,998	18,652	519,410	176,784	214,003	137,137	1,067,984
						MIDDLE SECTION			
OR-9	Jan-Feb 1937	41.2	Minor	Minor	9,521	3,091	3,163	2,437	18,212
OR-10	"	55.1	"	"	88,678	53,344	97,246	24,539	263,807
OR-11	Mar 1913	50.0	"	"	24,962	15,076	15,367	6,182	61,587
OR-12	"	23.0	"	"	18,506	7,712	7,678	5,887	39,783
Sub-Total		169.3	Minor	Minor	141,667	79,223	123,454	39,045	383,389
						UPPER SECTION			
OR-13	Mar 1936	10.0	Minor	Minor	35,840	10,753	8,791	5,603	60,987
OR-14	"	3.9	"	"	12,749	2,451	6,865	2,451	24,516
OR-15	"	3.7	"	"	2,188	2,071	12,492	10,561	27,312
OR-16	"	5.9	"	"	17,466	163,261	66,685	29,203	276,615
Sub-Total		23.5	Minor	Minor	68,243	178,536	94,833	47,818	389,430
Main Stem Total		1,160.6	1,998	18,652	729,320	434,543	432,290	224,000	1,840,803

Table 0-2

FLOOD PLAIN INFORMATION FOR MODIFIED(2) 100 YR FREQUENCY FLOOD

OHIO RIVER MAIN STEM

Reach(1)	Area Inundated (1000 Acres)	Damages ($1,000) Crop	Non-Crop	Residential	Commercial	Industrial	Other	Total
					LOWER SECTION			
OR-1	90.5	203	226	772	89	10	799	2,099
OR-2	245.0	551	870	1,274	209	51	1,530	4,485
OR-3	206.0	462	588	1,274	1,083	1,477	2,515	7,399
OR-4	112.5	252	3,096	2,585	316	137	296	6,682
OR-5	25.5	50	1,085	9,312	1,232	3,935	1,827	17,441
OR-6	25.5	54	271	2,870	1,267	1,161	1,494	7,117
OR-7	13.8	24	576	9,061	4,814	7,221	3,923	25,619
OR-8	9.0	17	486	4,952	1,084	331	933	7,863
Sub-Total	727.8	1,613	7,198	32,100	10,094	14,323	13,377	78,705
					MIDDLE SECTION			
OR-9	30.8	Minor	Minor	6,417	2,083	2,132	1,642	12,274
OR-10	41.3	"	"	33,941	8,675	61,812	8,823	113,251
OR-11	37.5	"	"	17,920	6,975	10,698	4,219	39,812
OR-12	17.5	"	"	12,427	4,423	7,842	5,729	30,421
Sub-Total	127.1	Minor	Minor	70,705	22,156	82,484	20,413	195,758
					UPPER SECTION			
OR-13	5.8	Minor	Minor	9,367	2,301	2,136	2,628	16,432
OR-14	2.0	"	"	1,855	662	3,447	662	6,626
OR-15	1.8	"	"	155	146	879	745	1,925
OR-16	2.7	"	"	2,016	10,262	2,428	3,326	18,032
Sub-Total	12.3	Minor	Minor	13,393	13,371	8,890	7,361	43,015
Main Stem Total	867.2	1,613	7,198	116,198	45,621	105,697	41,151	317,478

NOTE: (1) See Figure 0-4 for location of reaches.

(2) Modified by projects in the July 1965 flood control plan.

Table 0-3

OHIO RIVER STANDARD PROJECT FLOOD STAGES

Location	Flood Stage (Ft)	Maximum Flood of Record Stage (Ft)	Standard Project Flood Stage (Ft)	Standard Project Flood Stages As Modified By The July 1965 Plan[1] (Ft)	July 1965 Plus Potential Future Plans[2] (Ft)
Pittsburgh, Pa	25	46.0	55.2	43.0	34.3
Lock & Dam 12, Wheeling, W Va	36	55.2	71.1	60.7	51.1
St. Mary's, W Va	38	54.8	71.0	64.8	59.0
Pomeroy, Ohio	41	67.0	84.9	76.0	70.5
Huntington, W Va	50	69.4	85.5	76.7	66.3
Maysville, Ky	50	75.3	90.2	82.8	78.1
Cincinnati, Ohio	52	80.0	95.7	87.0	81.1
McAlpine Lock & Dam, Louisville, Ky	55	85.4	97.5	91.3	86.9
Evansville, Ind	42	53.8	58.0	56.0	54.7
Lock & Dam 51, Golconda, Ill	40	62.8	73.5	69.8	66.1
Lock & Dam 52, Metropolis, Ill	37	62.5	69.0	63.7	62.6

Table 0-4

NATURAL AND 1965[1] RESERVOIR MODIFICATIONS TO HISTORICAL FLOOD FLOWS ON THE OHIO RIVER

	March 1936				January-February 1937			
	Discharge (1,000 cfs)		Stage (Ft)		Discharge (1,000 cfs)		Stage (Ft)	
Location	Natural	Modified	Natural	Modified	Natural	Modified	Natural	Modified
Pittsburgh, Pa	557	357	46.0	35.0	351	255	34.5	29.0
Wellsville, Ohio	528	343	51.1	39.8	392	297	25.5	14.6
Lock & Dam 12, Wheeling, W Va	499	336	55.2	43.5	407	324	48.7	41.7
St. Mary's, W Va	403	285	46.9	38.0	391	317	50.0	43.5
Marietta, Ohio	413	285	48.1	36.0	513	356	55.0	40.5
Parkersburg, W Va	417	288	48.0	36.0	518	467	55.4	41.6
Lock & Dam 20, Belleville, W Va	437	308	50.7	40.3	542	409	58.6	47.1
Pomeroy, Ohio	448	367	55.6	48.8	543	422	64.5	54.2
Pt. Pleasant, W Va	450	344	54.4	44.3	543	388	62.7	48.9
Huntington, W Va	537	442	58.8	52.1	655	504	69.4	60.0
Ashland, Ky	567	467	62.7	55.9	693	542	73.6	64.0
Portsmouth, Ohio	560	477	59.2	52.8	734	592	74.2	63.5
Maysville, Ky	564	476	59.1	53.3	776	629	75.3	66.7
Cincinnati, Ohio	565	499	60.6	55.7	892	734	80.0	70.4
McAlpine Lock & Dam, Louisville, Ky	618	535	63.6	58.2	1,111	978	85.4	81.4
Evansville, Ind	667	582	44.4	43.0	1,332	1,173	53.8	52.1
Lock & Dam 51, Golconda, Ill	715	647	47.8	45.2	1,467	1,331	62.6	60.9
Lock & Dam 52, Metropolis, Ill	1,098	798	50.9	42.9	1,844	1,294	62.3	54.1

NOTES: (1) Modified by reservoirs completed, under construction and in preconstruction planning as of July 1965.

(2) Modified by reservoirs in the "July 1965 Plan" plus those likely to be in a potential future flood control plan to the year 2020.

Table 0-5

JULY 1965 FLOOD CONTROL PLAN

OHIO RIVER MAIN STEM

A. FEDERAL

MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65 (1) Status	Type of Project and Length in Miles Earth Levee	Concrete Flood Wall	Channel	Other
Wellsville, Ohio	C	1.1	0.4	-	
Parkersburg, W Va	C	1.8	2.0	0.4	
Pt. Pleasant, W Va	C	0.9	1.4	0.5	
Huntington, W Va	C	4.5	7.0	-	
Ceredo-Kenova, W Va	C	2.6	1.6	-	
Catlettsburg, Ky	C	1.2	0.7	-	
Ashland, Ky	C	0.1	2.6	-	
Ironton, Ohio	C	5.8	1.0	0.5	
Russell, Ky	C	0.3	-	-	
Portsmouth-New Boston, Ohio	C	4.0	4.0	0.9	
Maysville, Ky	C	1.2	1.5	0.1	
Newport, Ky	C	1.5	0.8	-	
Covington, Ky	C	1.9	0.9	-	
Cincinnati, Ohio	C	0.1	1.2	-	Barrier Dam
Lawrenceburg, Ind	C	3.5	0.2	-	
Jeffersonville-Clarksville, Ind	C	5.0	1.8	-	
Louisville, Ky	C	12.7	4.1	-	
New Albany, Ind	C	2.8	0.7	-	
Cannelton, Ind	C	0.7	0.9	-	
Hawesville, Ky	C	0.9	-	-	
Tell City, Ind	C	0.7	1.2	-	
Evansville, Ind	UC	18.9	2.5	-	
Uniontown, Ky	C	1.9	-	-	
Rosiclare, Ill	C	0.7	1.2	-	
Golconda, Ill	C	1.0	0.2	-	
Paducah, Ky	C	9.2	3.0	-	
Brookport, Ill	C	3.7	0.7	-	

B. NON FEDERAL

LOCAL PROTECTION PROJECTS

Project Location	Jul 65 Status	Remarks
Shawneetown, Ill	C	Levee Orgininally built by the city in 1875. Raised and enlarge in 1934 with Federal funds. Levee overtopped in 1937 flood.

NOTES:

(1) July 1965 Status

C - Completed

UC - Under construction

Table O-6

NATURAL AND MODIFIED(1) AVERAGE ANNUAL FLOOD DAMAGES
OHIO RIVER MAIN STEM

(July 1965 Price Level)

Reach(2)	Natural Damages ($1,000)							Modified Damages ($1,000)						
	Crop	Non-Crop	Residential	Commercial	Industrial	Other	Total	Crop	Non-Crop	Residential	Commercial	Industrial	Other	Total
LOWER SECTION														
OR-1	148	83	6,590	1,351	211	491	8,874	62	30	35	6	1	40	174
OR-2	322	167	596	192	33	303	1,613	235	126	68	11	9	165	614
OR-3	645	223	1,590	561	536	1,129	4,684	565	194	211	53	336	310	1,669
OR-4	162	1,620	1,556	270	129	201	3,938	100	1,174	100	13	8	288	1,683
OR-5	63	158	5,083	1,330	1,830	1,327	9,791	20	88	377	39	125	43	692
OR-6	125	110	4,010	1,802	1,391	1,466	8,904	88	72	164	83	149	274	830
OR-7	18	148	3,383	2,782	4,613	1,691	12,635	10	86	456	203	316	106	1,177
OR-8	15	106	827	174	40	213	1,375	8	52	198	52	6	18	334
Sub-Total	1,498	2,615	23,635	8,462	8,783	6,821	51,814	1,088	1,822	1,609	460	950	1,244	7,173
MIDDLE SECTION														
OR-9	Minor	Minor	623	189	193	150	1,155	Minor	Minor	110	36	37	28	211
OR-10	Minor	Minor	7,899	4,406	6,171	2,466	20,942	Minor	Minor	228	58	417	60	763
OR-11	Minor	Minor	1,462	1,204	671	388	3,725	Minor	Minor	183	63	146	49	441
OR-12	Minor	Minor	946	314	557	407	2,224	Minor	Minor	271	96	171	125	663
Sub-Total	Minor	Minor	10,930	6,113	7,592	3,411	28,046	Minor	Minor	792	253	771	262	2,078
UPPER SECTION														
OR-13	Minor	Minor	2,629	667	710	472	4,478	Minor	Minor	356	87	78	129	650
OR-14	Minor	Minor	687	228	1,189	229	2,333	Minor	Minor	111	26	92	41	270
OR-15	Minor	Minor	91	82	489	414	1,076	Minor	Minor	19	15	43	15	92
OR-16	Minor	Minor	802	7,222	2,937	1,335	12,296	Minor	Minor	82	464	144	329	1,019
Sub-Total	Minor	Minor	4,209	8,199	5,325	2,450	20,183	Minor	Minor	568	592	357	514	2,031
Main Stem Total	1,498	2,615	38,774	22,774	21,700	12,682	100,043	1,088	1,822	2,969	1,305	2,078	2,020	11,282

NOTES: (1) Modified by projects in the July 1965 flood control plan.

(2) See Figure O-4 for location of reaches.

Table 0-7

PROJECTED AVERAGE ANNUAL DAMAGES

OHIO RIVER MAIN STEM

Reach(1)	Average Annual Damages ($1,000)			
	Residual	Projected		
	1965	1980	2000	2020
LOWER SECTION				
OR-1	174	226	340	511
OR-2	614	799	1,151	1,574
OR-3	1,669	2,245	3,690	6,310
OR-4	1,683	1,991	2,785	3,652
OR-5	692	1,215	2,256	3,801
OR-6	830	1,374	2,514	4,277
OR-7	1,177	1,865	3,244	5,133
OR-8	334	522	852	1,271
Sub Total	7,173	10,237	16,832	26,529
MIDDLE SECTION				
OR-9	211	247	429	1,067
OR-10	763	1,659	2,256	3,589
OR-11	411	628	1,319	2,222
OR-12	663	663	1,606	3,475
Sub Total	2,078	3,197	5,610	10,353
UPPER SECTION				
OR-13	650	970	1,537	2,372
OR-14	270	395	617	955
OR-15	92	136	218	335
OR-16	1,019	1,564	2,620	4,036
Sub Total	2,031	3,065	4,992	7,698
MAIN STEM TOTAL	11,282	16,499	27,434	44,580

(1) See Figure 0-4 for location of reaches.

Table 0-8

POTENTIAL FUTURE FLOOD CONTROL PLAN

OHIO RIVER MAIN STEM

MAJOR LOCAL PROTECTION PROJECTS

Project Location	Jul 65[1] Status	Type of Project and Length in Miles Earth Levee	Concrete Flood Wall	Channel
Wheeling Island, W Va	I	1.7	1.1	-
Wheeling-Benwood, W Va	I	4.7	0.7	-
New Martinsville, W Va	D	1.1	1.0	-
Marietta, Ohio	I	1.6	3.3	-
Belpre, Ohio	D	0.9	1.4	-
Middleport, Ohio	D	-	1.5	-
Normal, Ky	I	1.2	-	-
Manchester, Ohio	I	1.7	-	-
Ripley, Ohio	I	1.2	-	-
Augusta, Ky	I	1.4	0.8	-
Moscow, Ohio	D	1.1	-	-
New Richmond, Ohio	I	1.1	0.7	-
California, Ohio	I	1.2	0.2	-
Cincinnati Unit #2, Ohio	I	5.8	0.7	-
Dayton, Ky	D	1.4	0.1	-
Cincinnati Unit #4, Ohio	I	-	2.4	-
Ludlow, Ky	D	1.1	0.4	-
Bromley, Ky	D	0.5	0.2	-
Aurora, Ind	D	0.7	1.2	-
Vevay, Ind	I	0.8	-	-
Carrollton, Ky	I	1.3	0.1	-
West Point, Ky	I	2.0	0.1	-
Mauckport, Ind	D	0.9	-	-
Lewisport, Ky	I	2.3	2.4	-
Grandview, Ind	D	2.9	-	-
Smithland, Ky	A	0.6	0.3	-

NOTES:

(1) July 1965 Status

A - Authorized project - Active Status

D - Authorized project - Deferred status

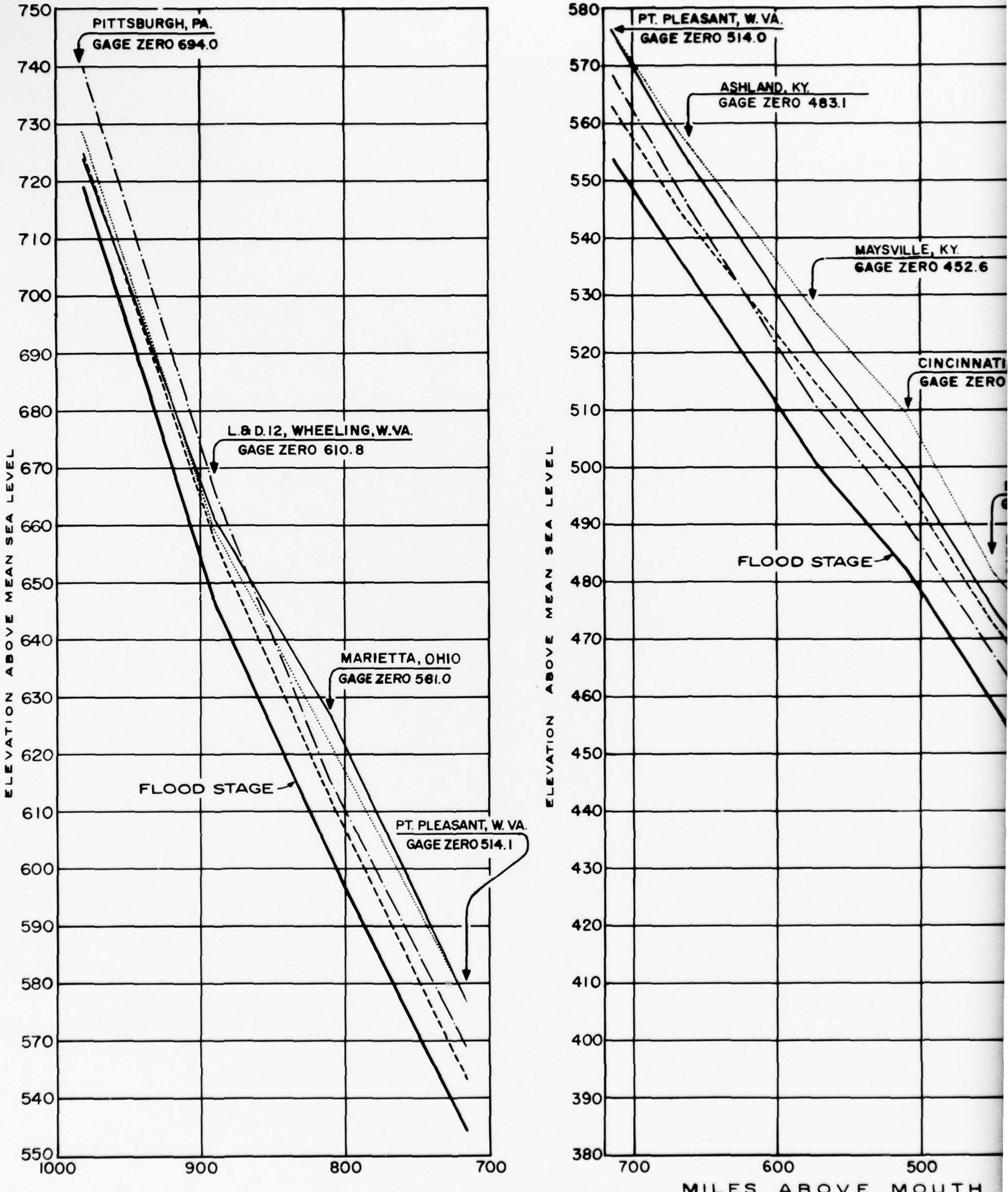
I - Authorized project - Inactive status

Table 0-9

SUB-BASIN FLOOD CONTROL STORAGES REQUIRED TO REDUCE THE OHIO RIVER STANDARD PROJECT FLOOD TO THE MAXIMUM FLOOD OF RECORD

Ohio River Sub-Basin	Storage Required(1) to Reduce the SPF to Maximum Flood of Record (1,000 Ac Ft)	Storage Available: July 1965 Plan (1,000 Ac Ft)	Storage Available: Potential Future Plan (1,000 Ac Ft)	Additional Storage Required Beyond the: July 1965 Plan (1,000 Ac Ft)	Additional Storage Required Beyond the: July 1965 & Potential Future Plans (1,000 Ac Ft)
Allegheny	2,869	1,713	442	1,156	714
Monongahela	1,634	429	951	1,205	254
Beaver	878	303	438	575	137
Muskingum	2,071	1,604	199	467	268
Little Kanawha	483	0	216	483	267
Hocking	296	18	175	278	103
Kanawha	1,391	1,252	1,320	139	0
Guyandotte	193	182	154	11	0
Big Sandy	1,192	339	196	853	657
Little Sandy	214	100	0	114	114
Scioto	1,834	580	242	1,254	1,012
Little Miami	455	359	347	96	0
Licking	1,156	439	779	717	0
Great Miami	481	248	226	233	7
Kentucky	1,350	910	1,039	440	0
Salt	1,390	0	1,000	1,390	390
Green	4,724	2,052	270	2,672	2,402
Wabash	15,031	1,321	5,438	13,710	8,272
Cumberland	5,031	5,031	1,022	0	0
Total Ohio River Basin	42,673	16,880	14,454	25,793	14,597

(1) Based on estimate of timing of peak flood flows and reduction of crest stage at specific locations.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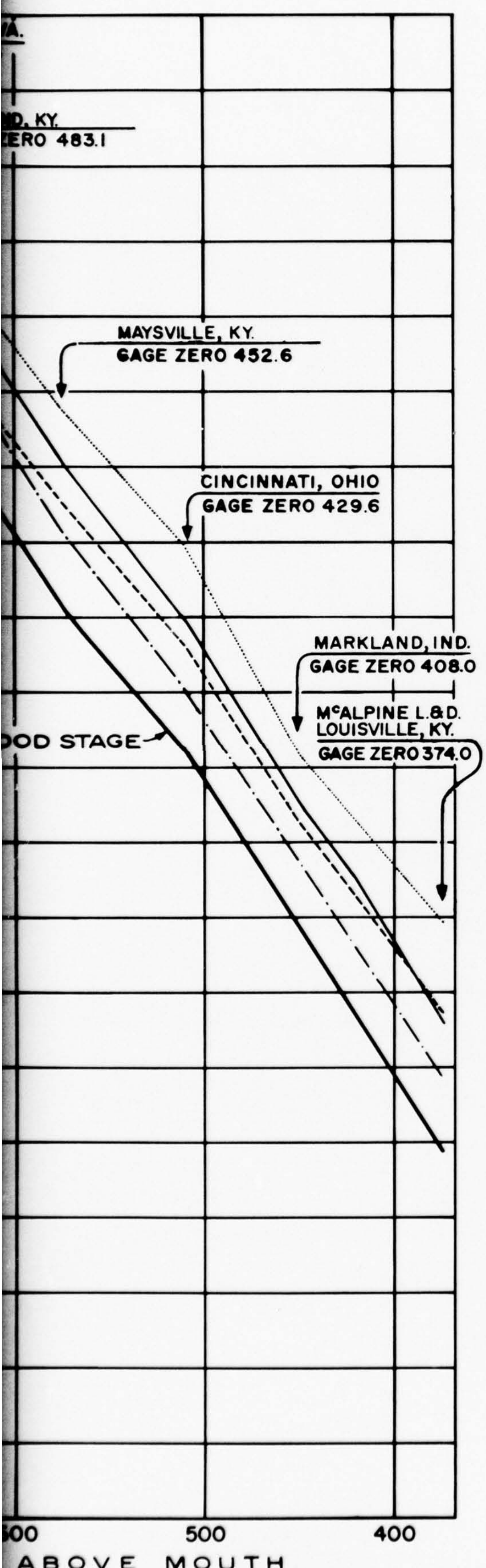
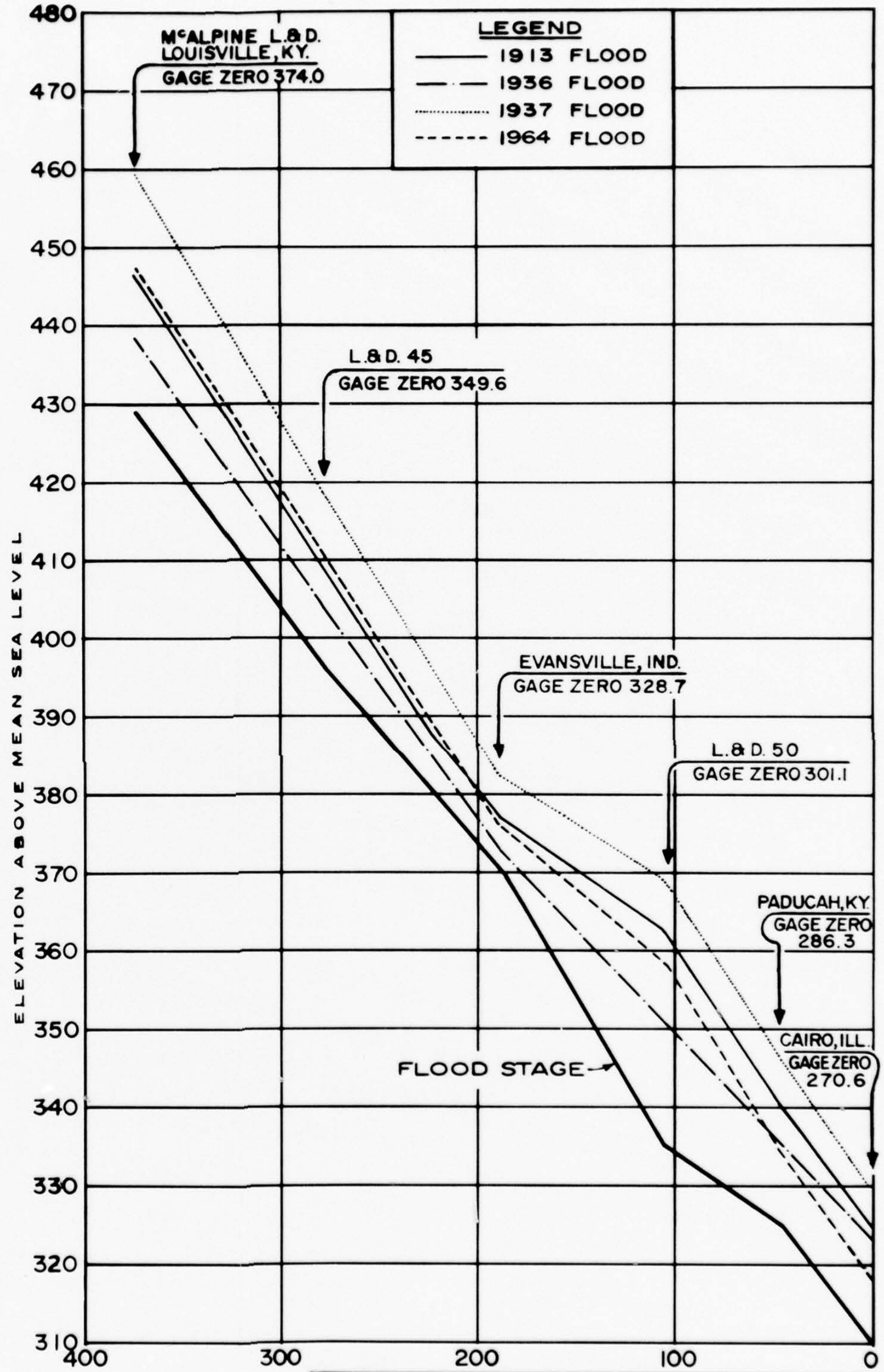
GAGE ZERO 610.8
MARIETTA, OHIO
GAGE ZERO 561.0
PT. PLEASANT, W. VA.
GAGE ZERO 514.1
FLOOD STAGE
PT. PLEASANT, W. VA.
GAGE ZERO 514.0
ASHLAND, KY.
GAGE ZERO 483.1
MAYSVILLE, KY.
GAGE ZERO 452.6
CINCINNATI
GAGE ZERO
FLOOD STAGE
ELEVATION ABOVE MEAN SEA LEVEL
ELEVATION ABOVE MEAN SEA LEVEL
MILES ABOVE MOUTH



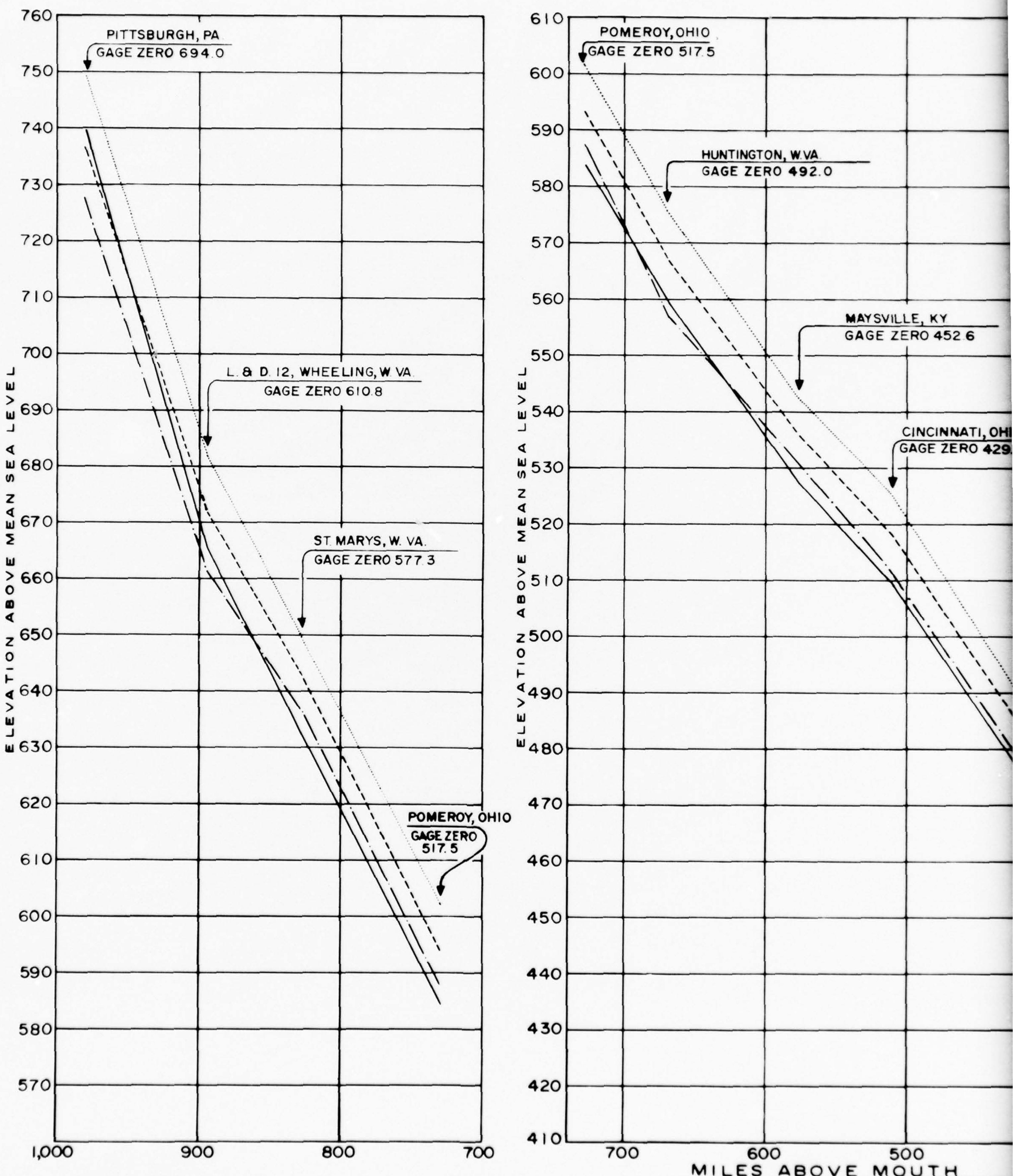


OHIO RIVER BASIN COMPREHENSIVE SURVEY

OHIO RIVER
FLOOD PROFILES

CORPS OF ENGINEERS U.S. ARMY, OHIO RIVER DIVISION

APPENDIX M FIGURE O – I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GAGE ZERO 610.8
ST. MARYS, W. VA.
GAGE ZERO 577.3
POMEROY, OHIO
GAGE ZERO 517.5
POMEROY, OHIO
GAGE ZERO 517.5
HUNTINGTON, W.VA.
GAGE ZERO 492.0
MAYSVILLE, KY
GAGE ZERO 452.6
CINCINNATI, OHI
GAGE ZERO 429.
ELEVATION ABOVE MEAN SEA LEVEL
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720
710
700
690
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660
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640
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620
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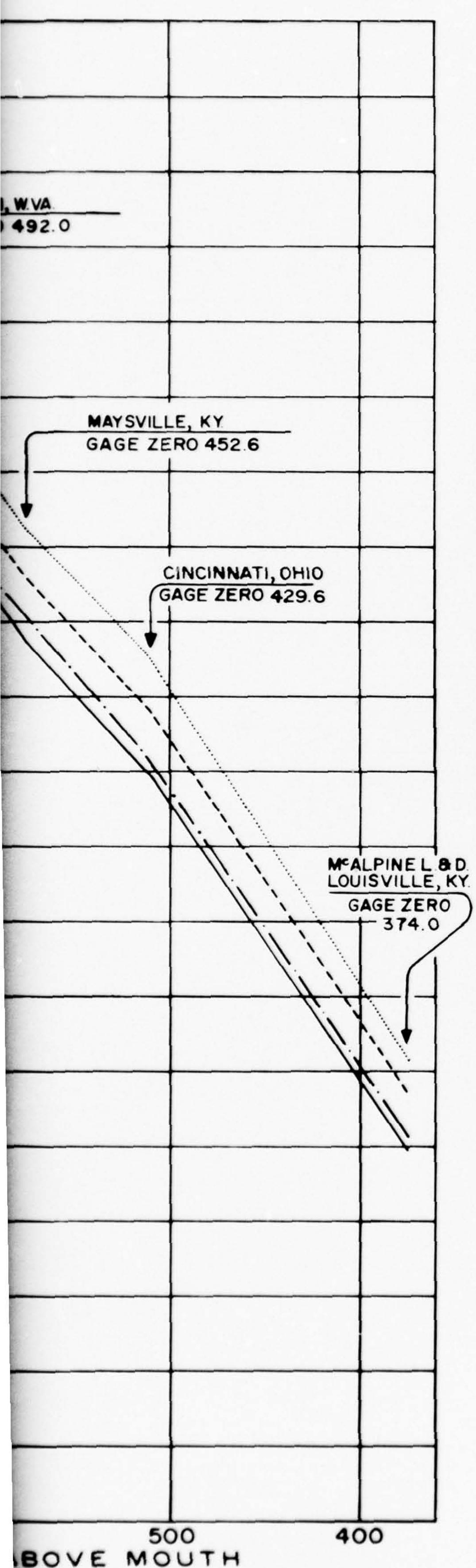
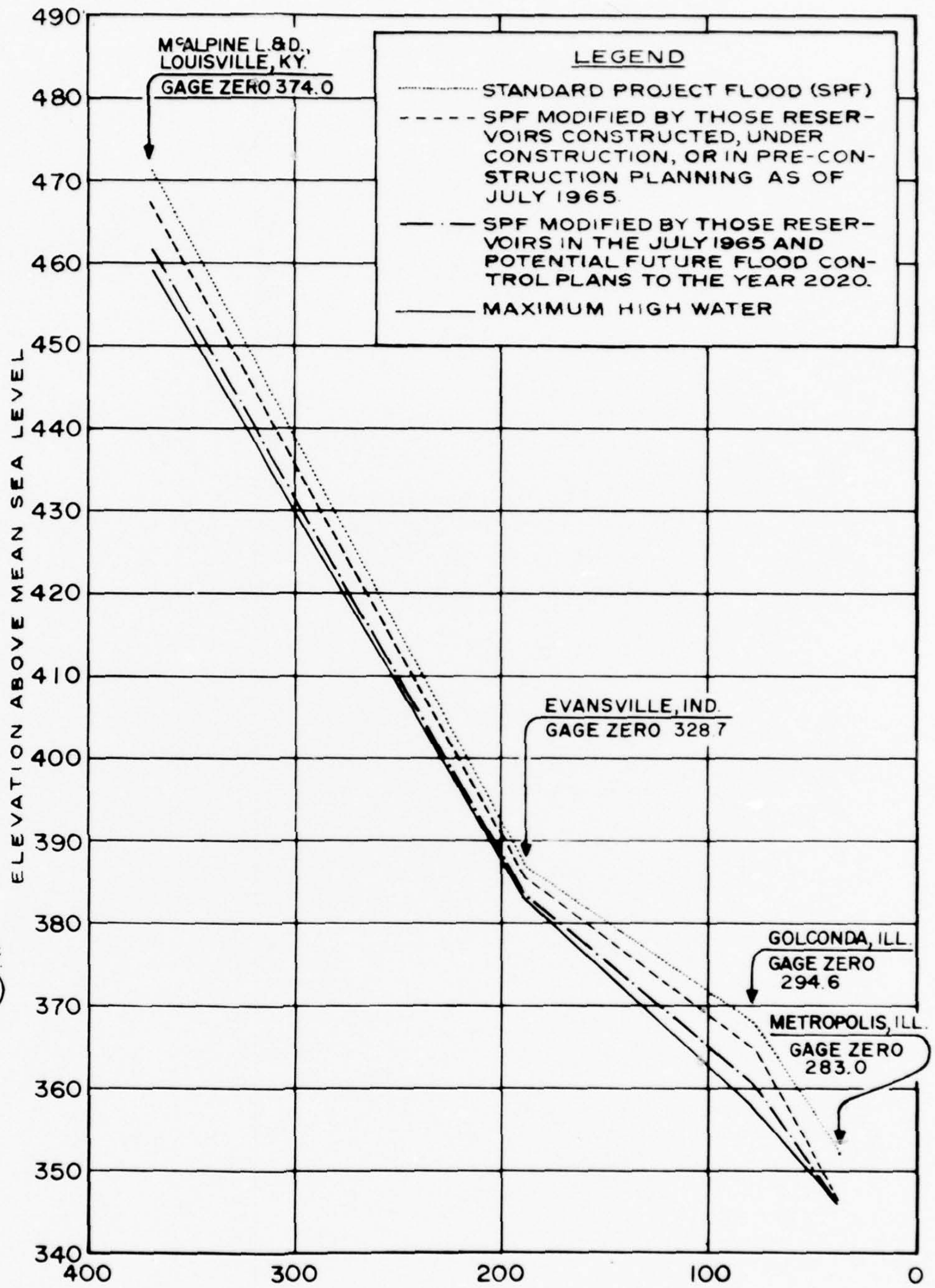
MILES ABOVE MOUTH



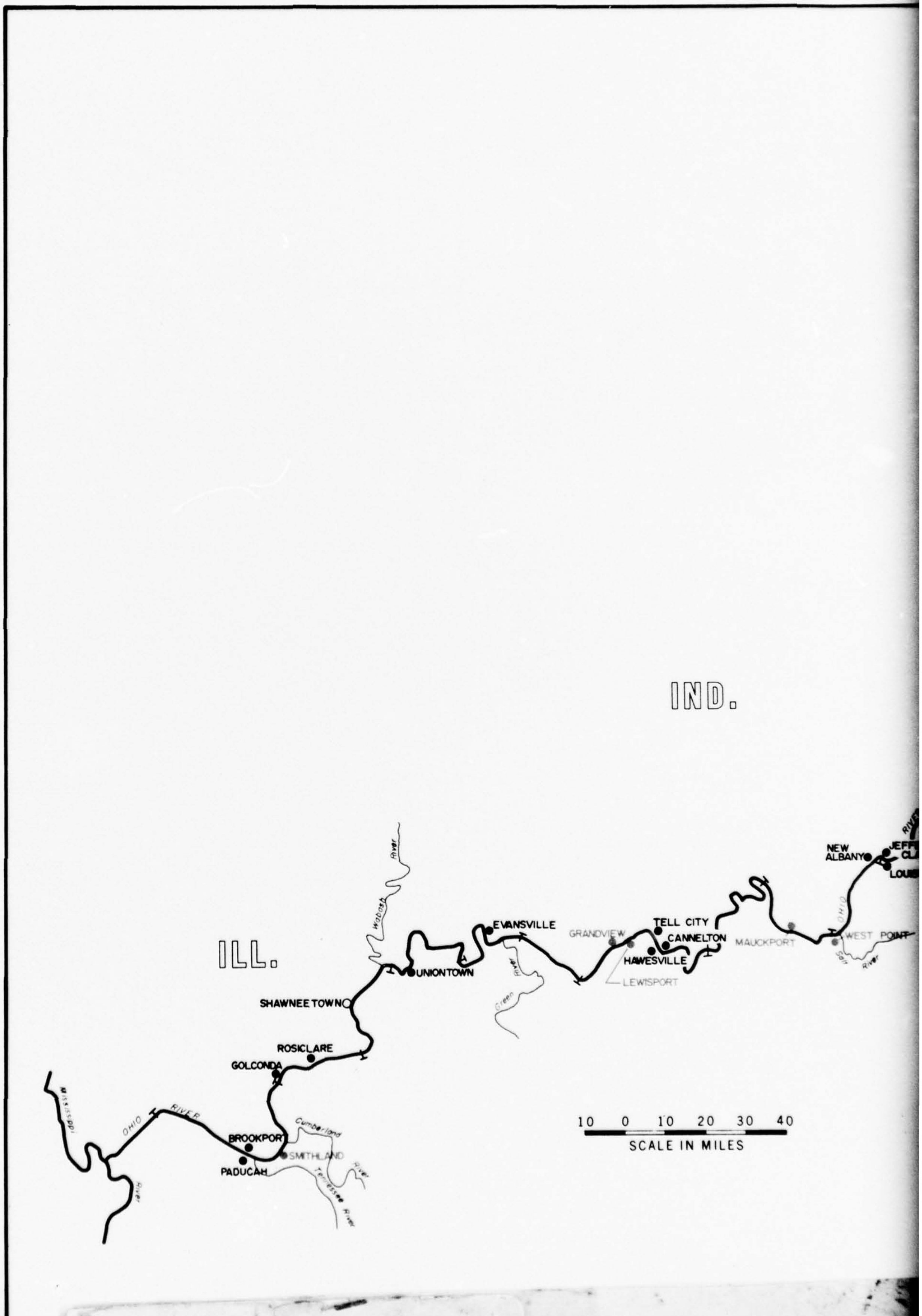


OHIO RIVER BASIN COMPREHENSIVE SURVEY

STANDARD OHIO RIVER PROJECT FLOOD PROFILES

CORPS OF ENGINEERS U.S. ARMY, OHIO RIVER DIVISION

APPENDIX M FIGURE O-2



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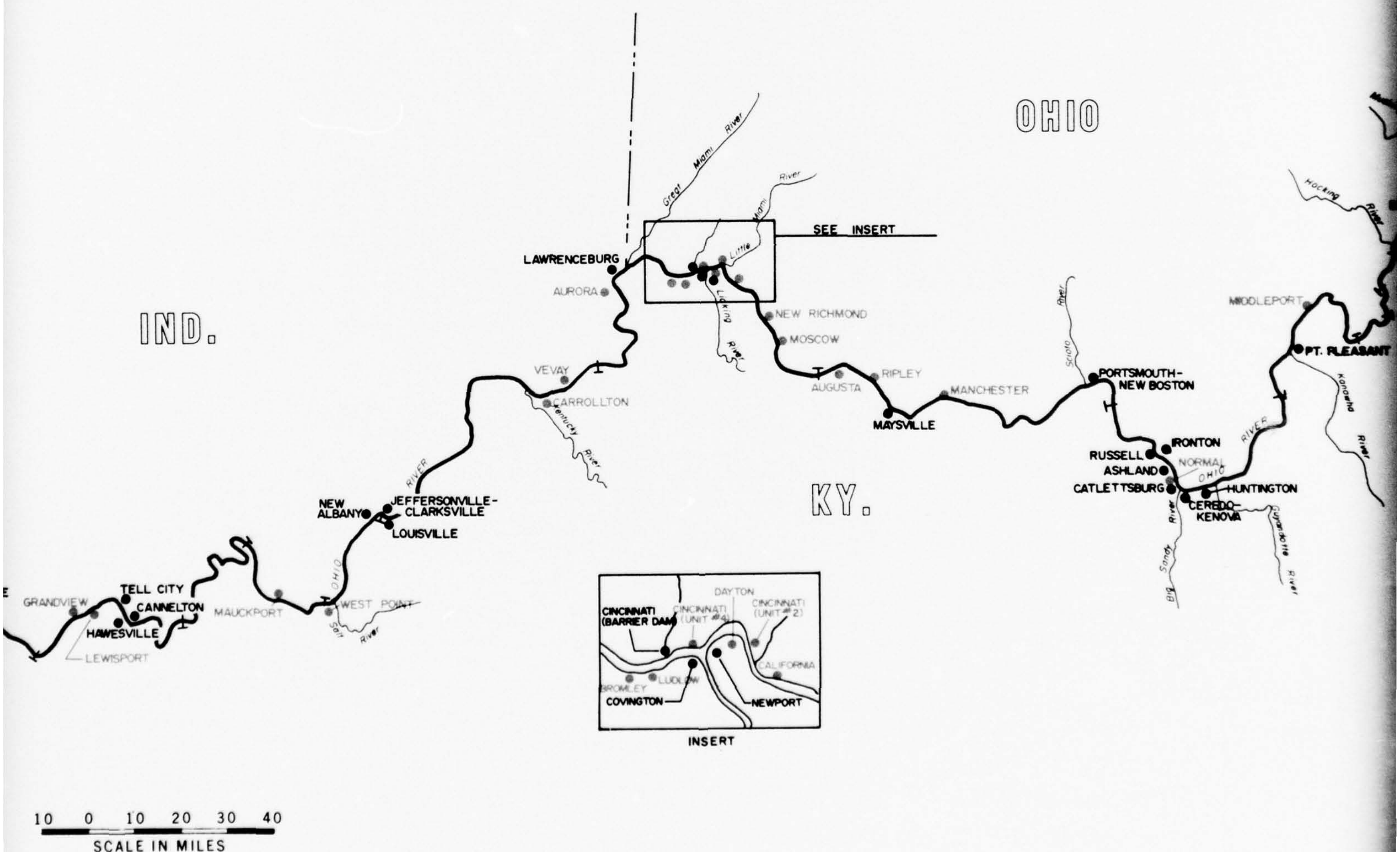
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KY.
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AURORA
VEVAY
CARROLLTON
Great Miami River
Little Miami River
Licking River
Kentucky River
NEW RICHMOND
MOSCOW
AUGUSTA
RIPLEY
MANCHESTER
MAYSVILLE
Scioto River
PORTSMOUTH-
NEW BOSTON
IRONTON
RUSSELL
ASHLAND
NORMAL
CATLETTSBURG
CEREDO-
KENOVA
HUNTINGTON
Big Sandy River
Guyandotte River
OHIO RIVER
MIDDLEPORT
PT. PLEASANT
Kanawha River
Hocking River
NEW
ALBANY
JEFFERSONVILLE-
CLARKSVILLE
LOUISVILLE
OHIO RIVER
WEST POINT
Salt River
MAUCKPORT
TELL CITY
CANNELTON
HAWESVILLE
GRANDVIEW
LEWISPORT
CINCINNATI
(BARRIER DAM)
CINCINNATI
(UNIT #4)
DAYTON
CINCINNATI
(UNIT #2)
CALIFORNIA
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COVINGTON
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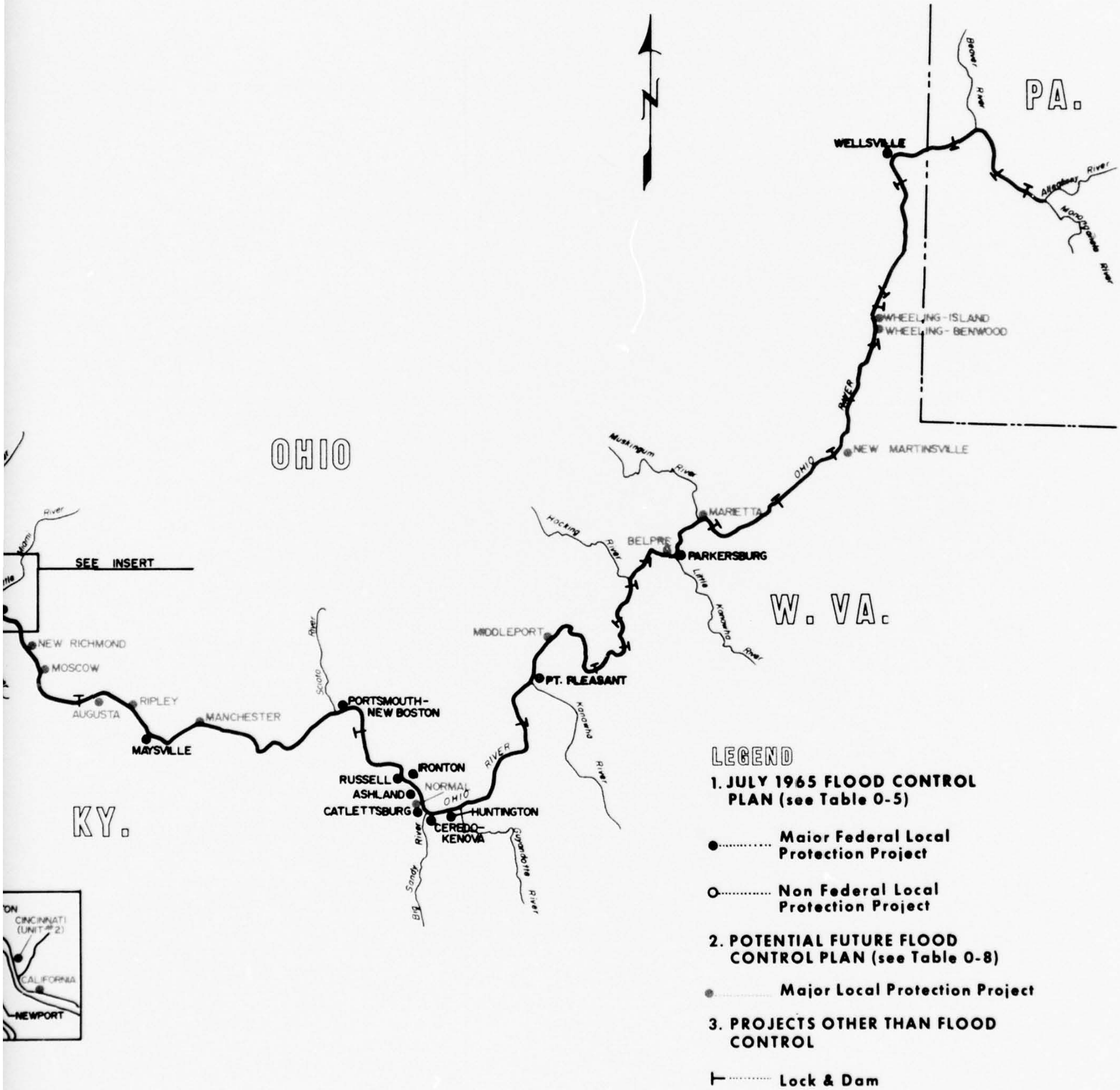
10 0 10 20 30 40
SCALE IN MILES

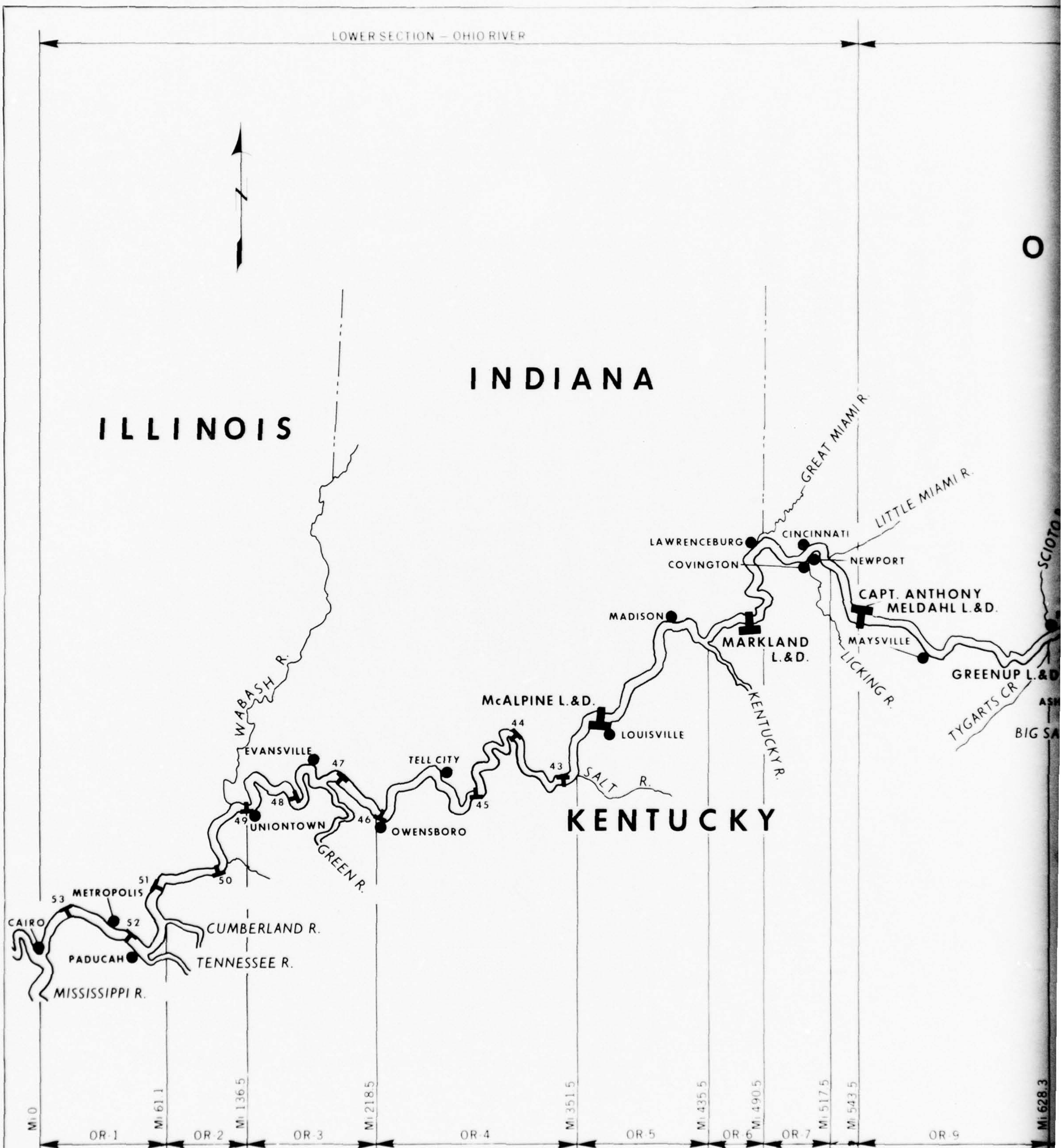


OHIO RIVER BASIN COMPREHENSIVE SURVEY

OHIO RIVER FLOOD CONTROL LOCAL PROTECTION PROJECT DEVELOPMENT AS OF JULY 1965

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE 0-3



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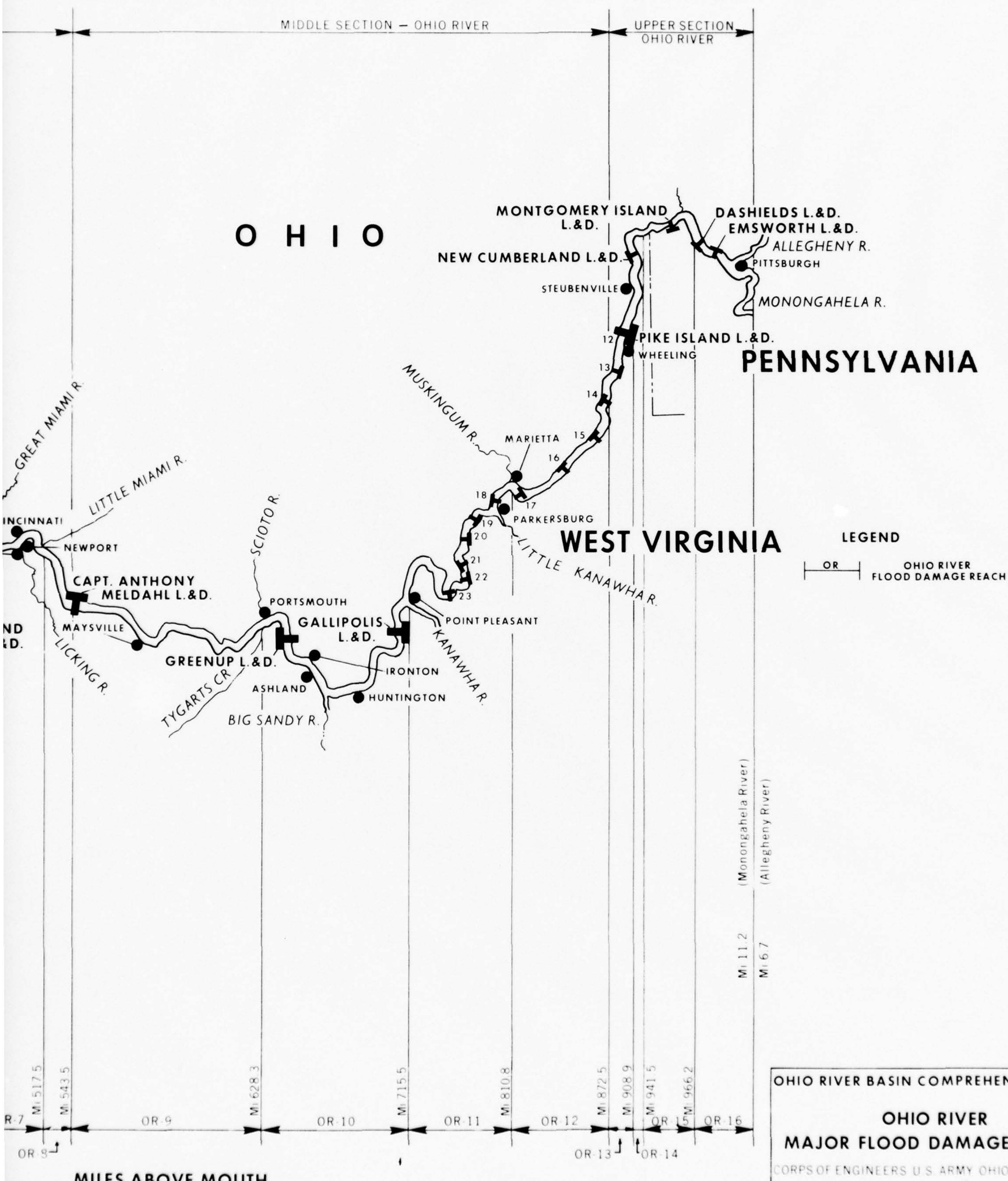


OHIO RIVER BASIN COMPREHENSIVE SURVEY

OHIO RIVER
MAJOR FLOOD DAMAGE REACHES

CORPS OF ENGINEERS U.S. ARMY OHIO RIVER DIVISION

APPENDIX M FIGURE 0-

SECTION III - POTENTIAL FUTURE OHIO RIVER BASIN FLOOD CONTROL PLAN

This study concludes that the flood problem in the Ohio River Basin is of such magnitude that it is one of the major factors to be considered in the optimum development and use of the basin's water and related land resources. If past trends are an indication of what can be expected in the future, there will be an increase in flood damages as economic growth in the basin continues.

The first step in the development of a future flood control plan for the Ohio River Basin is to define its objectives. It must be realized that the elimination of all flood damage is not physically or economically possible. Therefore, the plan should provide protection to permit a reasonable degree of development without excessive flood damage on an average annual basis, or without creating a false sense of security against rare floods which would encourage flood plain development resulting in future flood disasters.

The future flood control plan for the Ohio River Basin to the year 2020 represents the development of all structural and non-structural flood control and flood damage prevention measures as they become economically feasible to the year 2020. The plan has been evaluated as part of a multipurpose framework plan aimed at the optimum development and use of the resources of the overall Ohio River Basin and each sub-basin as presented in Appendix K, Development Program Formulation.

The implementation of the potential future flood control plan must be a collaborative effort at all levels of government and individual responsibilities, each assuming the responsibilities best fitted to it. A realistic division of Federal, State and Local levels of responsibility would consist of the following.

Federal

Federal responsibilities would include:

a. Flood damage reduction through construction of flood control projects in both upstream and downstream areas of the basin appears to hold great promise as a means of flood damage reduction. The Corps of Engineers, Soil Conservation Service, and the States and Commonwealths of the basin should continue and expand their planning and construction programs to implement the potentially feasible projects. Control of high flow is estimated to cost an additional $5.36 billion. (July 1965 constant dollars). See Figure 12. The potential projects would provide, for downstream areas, over 15 million acre-feet of flood control storage in 161 additional reservoirs, about 400 miles of levees and floodwalls and approximately 90 miles of channel improvement in 95 major and 48 small local protection projects. (Figures 13 and 14). For upstream areas the program would contain 616 potential watershed projects including 3.5 million acre-feet of flood detention

FIGURE 12:
OHIO RIVER BASIN FLOOD CONTROL PLAN TO 2020-
FLOOD CONTROL INVESTMENTS

LEGEND:

UPSTREAM WATERSHED

DOWNSTREAM PROJECTS

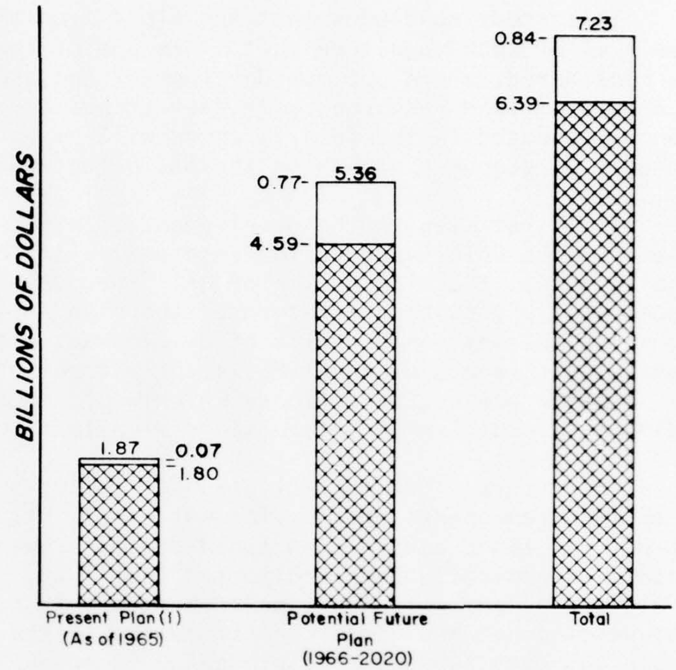
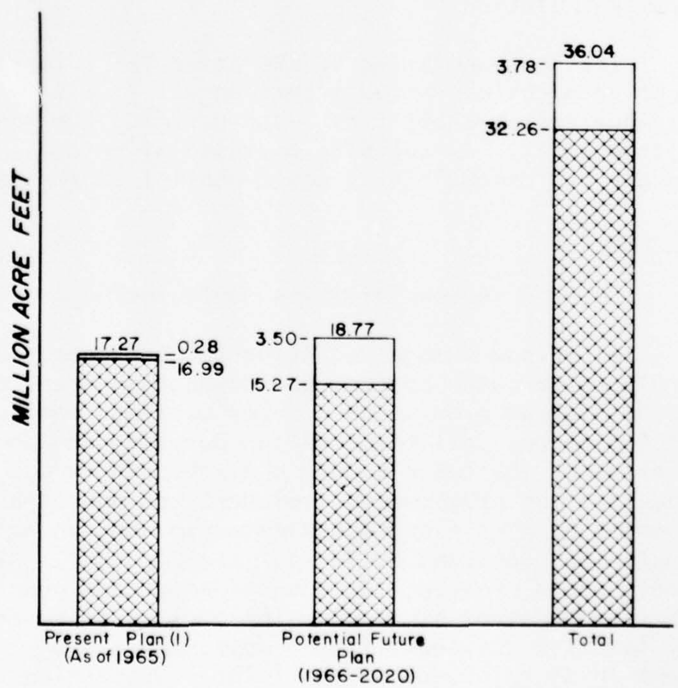


FIGURE 13:
OHIO RIVER BASIN FLOOD CONTROL PLAN TO 2020-
FLOOD CONTROL STORAGES



(1) Non Federal Projects Not Included

OHIO RIVER BASIN COMPREHENSIVE SURVEY
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APPENDIX M FIGURES 12 13

FIGURE 14:
OHIO RIVER BASIN IN FLOOD CONTROL PLAN TO 2020- ELEMENTS OF LOCAL FLOOD PROTECTION PROJECTS

LEGEND:

UPSTREAM WATERSHED PROJECTS

DOWNSTREAM PROJECTS

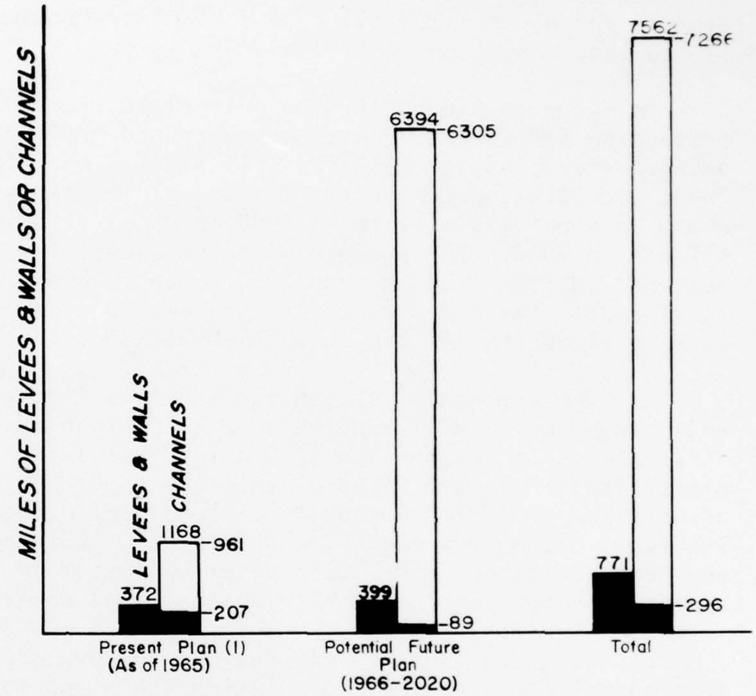
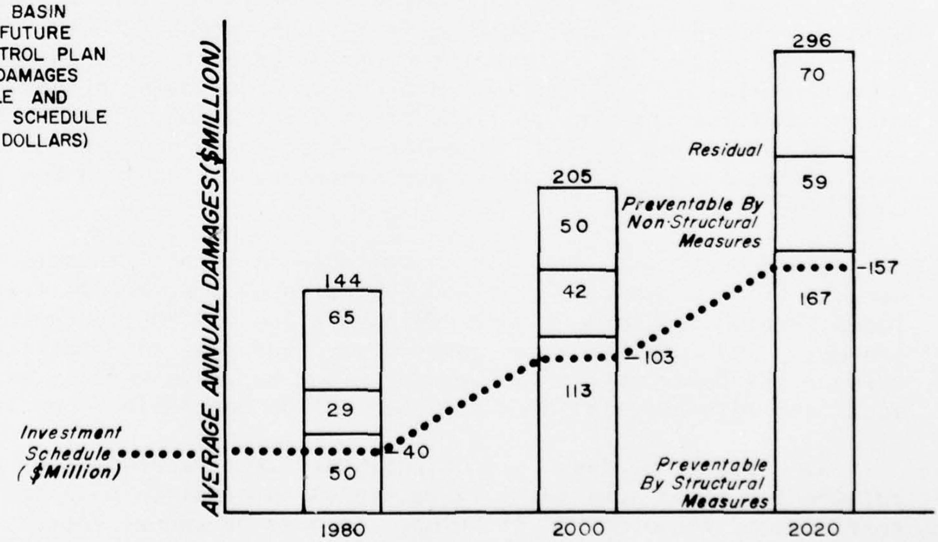


FIGURE 15:
OHIO RIVER BASIN POTENTIAL FUTURE FLOOD CONTROL PLAN TO 2020 - DAMAGES PREVENTABLE AND INVESTMENT SCHEDULE (JULY 1965 DOLLARS)



(1) Non-Federal Projects Not Included

OHIO RIVER BASIN COMPREHENSIVE SURVEY
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APPENDIX M FIGURES 14-15

storage and about 6,300 miles of channel or stream improvement. (Figures 13 and 14).

As shown on Figure 15, the potentially feasible reservoirs, local protection projects and upstream watershed projects could prevent damages averaging $50 million, $113 million and $167 million by 1980, 2000, and 2020 respectively. The annual investment for these projects would be about $40 million in 1980, $103 million in 2000, and $157 million in 2020. The average of these annual investments for the 40 year period from 1980 through 2020 would be about $100 million dollars annually as compared to the present (July 1965) annual investment rate in flood control projects of about $30 million.

b. The evaluation of optimum benefits from reservoir projects and related works will require a detailed land-use study of the flood plains of the basin. Such a land-use study would include: a classification of all flood plain lands as to present and future types of use; and projected intensity of land use in each classification. The flood plain area along the Ohio River should have high priority in any land use study, since Ohio River main stem flood control benefit evaluations are required for tributary flood control storage projects.

c. Cost sharing is a key feature in advancing national efforts to manage flood losses by stimulating State and local participation in the planning of investment and land use. A modification, at a National level, of present cost-sharing policy is timely for several reasons. Under present policy cost-sharing is not consistent for all Federal construction agencies. Furthermore, major benefits claimed for flood control works have shifted from protection of existing property to those resulting from future flood plain development. Therefore, the Federal investment is in reclamation rather than in preservation of existing development and the chances increase that only a few will become beneficiaries.

d. Federal loan assistance available to local interests to pay for certain flood prevention or flood control programs, are restricted to loans through the Farmers Home Administration for Public Laws 534 and 566 projects, and loans to local governmental agencies in depressed areas through the Department of Commerce. Flood problems warrant extension of such loan authority to cover all cases of demonstrable financial need.

e. Studies by the Corps of Engineers, the Department of Agriculture and other agencies provide useful information on areas subject to flooding, frequency of flooding, and average annual losses. In this connection, there is a need for an increased exchange of data between these agencies and a standardization between agencies of the techniques of determining flood losses and the design criteria for structures.

f. The delineation of flood-hazard areas in the basin is presently being carried out under the flood plain information program. These studies give basic data concerning flood potentials and conditions that are of much value in developing land use regulations and other preventative measures. To date about 43 studies have been authorized at a cost of about $830,000. The flood plain information program in the basin should be increased with special emphasis placed on the 46 major damage centers outlined in this report. A realistic flood plain information program in the Ohio River Basin to the year 2020 would consist of 700 or more additional studies at an estimated cost of about $18 million.

g. It is increasingly clear that non-structural measures should receive greater consideration in any program for reducing flood losses. Guides or pamphlets concerning the non-structural approaches to flood damage prevention need to be prepared and given wide distribution to engineers, planners, architects, local officials and citizen groups. Associated with this is the need for additional research on the benefits and the social and political aspects of their implementation.

h. Reliable, accurate, and timely flood forecasts are necessary to save lives and reduce property losses through temporary evacuation. The Weather Bureau of the Environmental Science Services Administration provides the primary flood forecasting service in the Ohio River Basin. This service has been and will continue to be invaluable in the saving of lives and dollars. Therefore, there is a need to expand this service to those areas not now covered.

State

To carry out the state responsibilities, recommended action if not already accomplished, should proceed along the following lines:

a. Studies of flood plain use show that some flood plain encroachment is undertaken in ignorance of the hazard, some occurs in anticipation of relief from the hazard by further Federal protection works, and some takes place because its sale or development may be profitable for the individual land owner even though it places heavy burdens on the rest of society. The enactment of legislation where it does not already exist, permitting state regulation of critical flood areas through zoning, and the establishment of the necessary machinery to administer and enforce flood plain zoning legislation is a must in any successful flood control program.

b. In order for the state government to prepare and promote a meaningful, integrated and comprehensive flood damage prevention plan at the local levels, state assistance must be made available to local agencies. This would be in the form of setting necessary standards for flood studies, rendering technical hydrologic service and assisting local agencies in planning, making use of flood evaluation reports, and preparing flood plain ordinances.

c. Since flood forecasting and warning systems can prevent loss of life and reduce flood damages, the states should assist local areas in establishing warning systems where these do not now exist. In some areas, state-local warning relationships might be established.

d. If they do not now exist, laws governing the construction and maintenance of dams across stream channels whose failure would increase flood loss and hazard to life downstream should be enacted by the states.

e. State Highway Departments should improve those flood prone stretches of highways and, wherever possible, give preference to relocation through flood-free lands.

Local-Public

Each locale in the basin is different from all others to some degree, and therefore, local flood control programs can be more accurately tailored to local needs than any standards imposed from above. Also, at this level of government individual development can be strongly guided. Therefore, it is recommended that local entities should consider the following:

a. Enact and revise existing ordinances to regulate flood plain use. In this connection a master plan of land use for the community should be prepared and planning commission should have legal authority to regulate land use.

b. The establishment of a flash flood warning system should be undertaken, making full use of elementary equipment and local radio, television, telephone and other communication systems.

c. Finally, community interest must be stimulated by holding local town meetings, forming public interest groups, and making available to property owners literature on flood hazards and their control.

Local-Private

Owners of property in the flood plain must participate actively with local officials in any flood control program. Structures, which must be located in the flood plain, should incorporate all the elements of flood proofing to reduce flood damages. Lending institutions can cooperate in this endeavor by requiring structures in flood prone areas meet certain building codes.

SECTION IV - METHODOLOGY EMPLOYED IN FLOOD DAMAGE STUDIES INVENTORIES AND PROCEDURES

This section contains information on flood damage studies compiled for the Ohio River Basin Comprehensive Survey. These include evaluations for July 1965 conditions of development in flood plains and estimates of future damages for projected conditions. Inventories were also made of present and possible future flood control projects and programs. From these, flood problems and potential solutions were analyzed. The findings are presented in other sections of the appendix, as appropriate.

For July 1965 conditions of development, project and flood damage data in downstream areas were supplied by the Corps of Engineers, while upstream information came from the Soil Conservation Service (SCS). In order that total basin flood damages could be presented, estimates were made of those in areas not covered by any surveys. Analysis of available Corps and SCS data provided a basis. Estimates of future damages for projected conditions of development were based on information from Appendix B, Projective Economic Study, and the Department of Agriculture's land use and productivity studies presented in Appendix F. For reporting purposes, the basin has been divided into 18 major hydrologic sub-areas, the Ohio River minor tributaries, and the Ohio main stem as denoted on Figure 11 in Section II. Because of differences in the type, coverage, and sources of available data, flood damages were compiled under two general headings, the Ohio River main stem and tributary sub-basins.

Inventory of Flood Damage Data

For sub-basins the inventory was a coordinated effort between the Corps and SCS. Corps districts tabulated available damages in terms of average annual, pertinent flood plain information and major flood damage centers as illustrated in tables in this appendix. The Corps used six damage classifications for downstream areas and SCS data for upstream areas were compiled using five damage classifications. However, these were compatible with those used by the Corps for the purpose of determining basin totals. Damage estimates for localities void of survey information were based on the judgement of Corps and SCS personnel, fragmentary data on the area, and generalizations reached from information on adjacent or similar areas.

For the Ohio River, damages were supplied by Corps districts; SCS upstream areas were not involved. Flood damage surveys were made for all areas along the Ohio. The Corps damage classifications and tabulated data are similar to those given for aforementioned sub-basins.

Inventory of Flood Control Projects and Programs

Data for the inventory on all present and potential Federal projects and programs were supplied by Corps districts and SCS field offices.

Information on non-Federal projects came from the states concerned, as found in Appendix J.

Procedures for Determining Downstream Flood Damages

Flood damage surveys were not undertaken in sub-basins in connection with the Ohio River Basin study. Surveys on many of the major tributaries are of recent origin as a result of the general investigation programs. Tributaries with recent surveys include the Hocking, Little Kanawha, Scioto, Big Sandy, Guyandotte, Kentucky, Green, Wabash, and Cumberland Rivers. Flood damage surveys in the Kanawha and Wabash River Basins are being accomplished in the current comprehensive studies of these two. In general, past flood damage surveys on tributaries were considered to be adequate for a framework study.

Flood damage data along the Ohio River was very limited and much outdated; consequently, survey work was required for the present comprehensive study to enable a reasonable evaluation of the adequacy of the flood control plan. The Ohio main stem has been divided into 16 reaches for study purposes as indicated on Figure 0-4.

The survey methods used for determining flood damages along the Ohio main stem originated from practices developed from tributary studies and other work. General procedures were:

a. Visual inspections were made of all property within the flooded areas. Contacts were made with officials of industrial firms, large commercial establishments, utilities, railroads, highways and public properties to obtain values of flooded properties and estimates of losses.

b. Small commercial firms that could be logically associated as to size, service performed, location, flood depth, and the like, were in some instances grouped after obtaining representative samples.

c. Residential properties were visually examined and 10 to 20 percent of the owners or occupants interviewed. Properties with similar features, values, flood heights and flooding depths were grouped, and damage tables used as a guide to determine losses. The reason for the inspections was to check actual flood elevations, determine if any unusual conditions existed that should be reflected in the survey, assist the appraiser in determining changes in real estate values between areas, and check the validity of flood damage tables.

d. Agricultural properties were evaluated by representative field sampling methods. Property values, land use, damage to buildings, fences, lands, and the like, were obtained from owners or estimated with their assistance. Areas covered by the samples were expanded to include the entire agricultural flood plain area. This was determined by placing flood contours on latest available crop lands and measuring the areas inundated for each flood elevation.

e. Stage-damage, stage-discharge, and discharge-frequency relations were developed on a reach basis or for a series of reaches as related to a particular stream gage throughout the Ohio River Basin. Correlation of the relationships was used to develop damage-frequency curves for determination of average annual damages. Available data have been assembled and converted to a common time basis, July 1965, which means that price levels, developments in flood plains, and status of projects are on the same basis.

Flood Damage Projection Methodology

Projected average annual flood damages to 2020 were derived by applying an index of change to current (1965 development) damages for each of the following six categories: agricultural crop, agricultural non-crop, urban-residential, commercial, industrial, and other. Included in the "other" classification are erosion and sedimentation other than agricultural, public properties and services, communications, utilities, transportation and marine facilities, and relief and public health services.

Indices of change for the foregoing categories were developed, using as a base the 19 economic sub-area projections of population and industrial output, total Ohio River Basin personal income, and national consumer expenditure patterns from Appendix B. Changes and crop yields in flood plain land use from the agricultural economic base study, Appendix F, were also considered. Available flood plain data consisting of population, local studies, and USGS maps were used to adjust the indices before determining the average annual damages. Additionally, judgment on land use and its availability was employed to modify indices before application to a particular flood plain area.

Agricultural crop average annual damages were projected by using sub-area indices of change in acres and in yields. Their product indicates the index of change for total productivity (or value of the crop land) and for average annual crop damages.

Agricultural non-crop damages were assumed to be comprised of farm buildings, equipment, and the like, and their losses closely associated with crop losses. Therefore, they were projected to change at the same rate as crop damages for a particular area.

Urban-residential damages were projected using indices of change in number of households and in consumer expenditures for housing and household goods. Change in the number of households reflects the change in the number of residential units, while the change in expenditure levels for housing and household goods per household reflects changes in value for units. The product of the two indices gives an approximation of the index of change in the total value of residential property in an area and in average annual flood damages. Population data for towns in the flood plain together with the general characteristics of area and surrounding areas were used to adjust the sub-area's

rate of change in number of households. Thus a realistic rate of change for the flood plains was obtained.

Change in spending for housing and household goods per household was derived using projected national patterns of consumer expenditure, and relating these to estimated sub-area personal income. For the total Ohio River Basin, the ratio of future personal income to output was derived and was applied to sub-area dollar output projections to obtain their personal income. This latter was multiplied by the projected share of expenditure on housing and household goods. This yielded the total sub-area expenditure on these goods. From the Projective Economic Study, the number of households by sub-area was used to determine the index of change in expenditure on housing and household goods per household. This change in value per unit multiplied by the estimated change in number of units gave the total change in value of residences.

Commercial average annual damages were projected on the basis of an index of change in the total expenditures for "commercial" goods and services per capita. This index, in conjunction with change in population, reflects the changes in value of commercial property in an area and in commercial average annual damages. The index was derived on a sub-area basis in much the same manner as that for the foregoing discussed housing and household expenditures. The share of total estimated sub-area personal income expended on commercial goods and services was projected and divided by the population to get the per capita basis. The change in commercial expenditure per capita multiplied by the estimated change in population for the service area yields a change in total expenditures on commercial goods and services, and so an index of change in value of commercial property and flood damage is derived.

Industrial average annual flood damages were projected on the basis of an index of change in manufacturing output total from the Projective Economic Study, or those in specific industry production levels. The latter was used if it was apparent that their present or future locations would influence the projections. The change in manufacturing dollar output will generally reflect changes in value of structures and equipment and in average annual industrial damages.

All "other" average annual flood damages were projected to change at the same rate as a composite of the aforementioned five categories. The total average annual losses for a particular area are the summation of the individual projections of the six damage categories.

Procedure for Determining Upstream Flood Damages

Upstream watersheds were delineated on topographic maps in sizes comparable to existing and contemplated Public Law 566 type projects. These latter were used as basic investigative units in appraising their potential for solving the agricultural and rural community problems.

Reconnaissance and map studies were made in upstream areas where data were inadequate to meet the requirements of a comprehensive framework (Type I) survey. The purpose was to determine by limited observation the flood problems that appear to have feasible solutions under Public Law 566. Based on this reconnaissance, supplemented by information supplied by agricultural workers familiar with the area and local residents, each watershed was classified into one of the following categories:

a. Where the need for watershed protection projects was clearly discernible and available storage sites would be economically justified in alleviating damages;

b. Where project feasibility for flood prevention purposes were questionable; and

c. Where there is little or no flood damage problems and water resource development potentials are limited.

Within each watershed, investigations were conducted in sufficient detail to complete estimates of natural damages. Additional data were developed for the watersheds in categories a and b. These included the kind, number, and amount of structural measures needed, the estimated acre-feet of sediment and floodwater retarding storage, and additional acre-feet of storage available for other uses. Also included were the estimated costs for installation and maintenance of needed structural improvements.

In the inventory, planning specialists and technicians developed pertinent field data. Estimates of the present use and flood free yields of flood plain land were prepared. Composite crop and pasture values were calculated for those areas subjected to inundation using flood-free yields and projected long-term prices. The physical characteristics of the flood plain and frequency and duration of flooding were studied along with resultant damages, and season of occurrence. These data were compared with those obtained during work plan development or detailed studies in similar watersheds. Floodwater damage estimates were made by using the statistical analysis of Public Law 566 work plans within the study areas and data developed over a long period of time by the state soil conservation technicians.

Assumptions were based on data from detailed work plans in similar areas as to the reduction of damages in the upstream agricultural areas to an acceptable level (a 3 to 5 year frequency). This was based on the reductions to be effected by land treatment measures and that attributable to floodwater retarding structures by the degree of control afforded. The channel improvement works required to carry the storm runoff from uncontrolled areas, and the release rates of the floodwater retarding structures were based on field information and map studies.

The total installation cost of floodwater retarding structures was estimated from curves showing the cost per square mile of drainage area controlled, or cost per acre-foot of flood prevention storage versus area controlled. Data used in developing these curves were based on recent contract costs and/or engineering estimates made in detail work plans of similar watersheds. Channel improvement cost estimates, based on available data, were expressed in terms of cost per mile of improvement applied to similar areas. Adjustments were made to account for any known field conditions that would cause construction expenses to exceed the average, and to account for low or high cost sites. Based on an interest rate of 3.125 percent for Federal borrowing, the factor .03979 was used to express the total installation costs as an average annual value.

Procedure for Projecting Upstream Flood Damages

The procedure for projecting upstream average annual flood damages is based on the assumptions that: (1) flood risk factors will continue to be ignored, and (2) a continuing growth can be expected in agricultural technology. The factors used for projecting crop and pasture damage to 1980, 2000, and 2020 were derived by comparing present flood plain land use and yield levels to the projected agricultural levels for each of the basin sub-areas. In upstream areas of sub-basins where crop and pasture damage was 70 percent or more of the total damages, all other losses were projected at the same rate. In determining potential flood damages for sub-basins where transportation and urban losses exceed all other types, consideration was given to basic elements as population, industrial and manufacturing growth based on information shown in Appendix B. Map studies and construction trends within the upstream watershed areas were also considered in determining a composite growth factor for each sub-basin. These factors were applied to average annual damages under present development for projecting flood losses under future conditions.

SECTION V - SUMMARY

Past floods in the Ohio River Basin have resulted in enormous damage, considerable human suffering, and loss of life. The great floods of this century occurred in March 1913, March 1936, and January-February 1937. The 1937 flood was the most disastrous ever experienced in the basin, inflicting severe damage over practically the entire area. The 1913 flood caused major damage north of the Ohio, but it was moderate to the south. The 1936 flood inflicted heavy losses in the upper section of the basin, and relatively minor damages elsewhere. More recent floods of January 1957, January 1959, March 1963, and March 1964, have caused extensive flooding along most major tributaries. On some tributaries, these recent floods are the maximum recorded, and all have resulted in significant flooding along the Ohio River.

Control of floods in the basin followed the great flood of March 1913, when the Miami Conservancy District was formed, and pioneered in the development of flood control works. Other entities followed this successful program to solve local and tributary flood problems. Although the Federal Government expressed national concern following the 1913 flood, it was not until after 1927 that studies on a Federal level using a basin-wide approach were undertaken and established the concept of multipurpose development. The implementation of a Federal program in the basin was not initiated, however, until after the disastrous floods of 1936 and 1937. The 1936, 1937, and 1938 Flood Control Acts initiated basin-wide control programs by authorizing a comprehensive plan of reservoirs and local protection projects.

The July 1965 flood control plan for the basin gives consideration to Ohio River and tributary basins. The effect of individual tributary plans on the Ohio River is evaluated and modified as justified from the standpoint of Ohio River control. Supplementary measures are then developed for the Ohio in the form of local protection. Other functional aspects of water resources that can be combined in the plan with flood control are considered. Included in the July 1965 Federal flood control plan for which post authorization funds have been provided are 75 reservoirs, 86 major and 56 small local flood protection projects in downstream areas, and 74 authorized watershed projects in upstream areas. These projects provide over 17 million acre-feet of flood control storage, 372 miles of levees and floodwalls, and 1,168 miles of channel improvement. In addition, 7 structures containing storage for flood control and numerous local protection projects have been or will be constructed by non-Federal interests.

The Ohio River Basin also has a flood forecasting and warning service operated by the Weather Bureau of the Environmental Science Services Administration. This provides time, in most instances, for evacuation of people and for protection of property and removal of some content from flood plains. The service is becoming more valuable as flood plain use intensifies, especially on the main stem and its major tributaries.

Flood damages for the Ohio River Basin under 1965 conditions of prices and development would have been $350 million annually were it not for the present flood control and flood damage prevention plans, which have reduced flood damages to about $111 million annually. Of the $239 million in damages prevented, reservoirs accounted for $160 million, flood forecasting $34 million, local protection projects $28 million, non-structural measures other than flood forecasting $15 million, and upstream watershed projects $2 million.

The effectiveness of July 1965 flood control and flood damage prevention programs can also be measured in terms of flood plain acreage receiving protection. There are an estimated eight million acres in the flood plains of the Ohio River Basin which require control of high flows. Presently about 3.6 million acres receive some protection, with about 865,000 acres receiving a relatively high degree of protection.

With the residual annual damages after completion of July 1965 program projected to increase from $111 million to $296 million in 2020, it is apparent that additional steps must be taken to reduce the hazard to the life and welfare of the people and the economic loss in resources and productivity in the region. The solution lies in comprehensive flood damage prevention programs which would include land use regulations and other non-structural measures as well as control and prevention works.

The structural aspects of the future Ohio River Basin flood control plan includes 161 reservoirs, 95 major and 48 small local protection projects, and 616 potential upstream watershed projects in addition to the July 1965 flood control plan. This represents about 19 million acre-feet of flood control storage, 400 miles of levees and floodwalls and over 6,390 miles of channel improvements. The non-structural aspects of the future program includes land use regulations and other non-structural measures such as land treatment measures, floodproofing, flood forecasting, development policies, tax adjustments, and a program of public information and education. These preventative measures will require close cooperation and coordination between all levels of government. In addition, many flood plain studies must be made to identify the magnitude of the flood problem along the Ohio River and various tributary flood plains. It is estimated that 700 or more flood plain information studies will be undertaken throughout the Ohio River Basin.

In terms of cost, the investment in the present flood control plan amounts to about $1.9 billion. Through Fiscal Year 1966, about $1.28 billion had been appropriated, leaving about $510 million to complete this plan. The investment cost for the reservoirs, watershed projects, and local protection projects included in the future plan amounts to about $5.36 billion.

The future flood plain information program to 2020, consisting of 700 or more additional studies in the basin, is estimated to cost $18 million, with annual expenditures expected to reach $300,000 within a few years.

The development and implementation of a successful comprehensive flood control plan for the basin will require the coordinated efforts of all levels of government. The appropriate role of nonstructural measures will necessitate positive action programs by the states in conjunction with local governments to achieve effective control.

PHOTOGRAPH CREDITS

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